

2x600MW Training Manual

(20110223)



中国哈尔滨汇通电力工程有限公司 发布

Issued by **Harbin Huitong Electric Power Engineering Co., Ltd.**

Indian Mahan Project 2x600MW Power Station Training Manual of Boiler



哈尔滨电站工程有限责任公司

HARBIN POWER ENGINEERING COMPANY LIMITED



哈尔滨汇通电力工程有限公司

Harbin Huitong Electric Power Engineering Co., Ltd.

CONTENT

1	Main Parameter and Operation Condition of Boiler	7
1.1	Capacity and Main Parameter of Boiler	7
1.1.1	BMCR Condition.....	7
1.1.2	TMCR Condition.....	7
1.2	Design Basis	8
1.2.1	Fuel.....	8
1.2.2	Steam and Water of Boiler Requirements	10
1.2.3	Classification of Construction Site is II.....	11
1.2.4	Main Design Characteristic	11
1.2.5	Account Data Table of Prospective Function for Boiler	14
2	Boiler Body.....	15
2.1	Drum	15
2.1.1	The Drum Internal Equipment.....	16
2.1.2	Control Value of Drum Level	17
2.2	Economizer	17
2.2.1	Structure Instruction	17
2.3	Furnace and Water Wall.....	18
2.4	Superheater and Reheater	22
2.4.1	Superheater	22
2.4.2	Reheater	24
2.4.3	Superheater and Reheater Protection and Control	25
2.4.4	Desuperheated Water System of Superheater and Reheater	26
2.4.5	Superheater and Reheater Operation Maintenance and Inspection.....	27
2.5	Soot Blowing System, Flue Gas Temperature Probe	28
2.5.1	Soot Blowing System	28
2.5.2	Flue Gas Temperature Probe.....	29
2.6	Safety Valve	31
2.7	Boiler Circulation Pump	31
2.7.1	Air Carryover.....	32
3	Air and Flue Gas System.....	33
3.1	ID System.....	33
3.1.1	Fan Main Parameter.....	33
3.1.2	Performance Parameter of Fan	33
3.2	FD System.....	34
3.3	Air Heater.....	35
3.4	Electro-Static Precipitator.....	36
3.4.1	Electrical Portion	36
3.4.2	Mechanical Portion.....	37
3.4.3	Earth.....	37
3.5	Flame Detection Cooling Fan.....	38
3.6	Stack.....	38
4	Milling System of Boiler	38
4.1	Mill Overview.....	38
4.2	Principle and Process of Mill Operation.....	39

4.3	Primary Air System.....	40
4.4	Seal Air Fan.....	41
4.5	Coal Feeder.....	41
4.6	Control and Adjustment of Milling System	41
4.6.1	Adjustment of Clearance between Grinding Roll and Grinding Bowl.....	41
4.6.2	Incorrect Phenomena During Mill Operation.....	44
4.6.3	Fire-proof of Milling System.....	45
5	Combustion System of Boiler.....	47
5.1	Design Coal Characteristics of the Power Plan.....	47
5.2	Burner	48
5.3	Fuel Oil System	48
5.4	Fire Supervisory and Industrial Television.....	49
5.5	Burner Management System (BMS)	49
5.5.1	Public logic part.....	49
5.5.2	Oil System Control:	50
5.5.3	Coal System Control.....	50
6	Boiler and the Another Auxiliary System.....	50
6.1	Industrial Cooling Water System of Boiler Auxiliary	50
6.2	Boiler Expansion System.....	50
6.3	Supervisory System of Transpiration for Boiler Pipe	53
6.3.1	Main function.....	53
7	Boiler Start.....	54
7.1	Boiler Cold Start	54
7.1.1	Check Operation Regulation before Boiler Startup	54
7.1.2	Main Steps of Startup:	55
7.2	Boiler Warm Start	58
7.2.1	Main Steps of Startup:	58
7.3	Boiler Hot Start.....	61
7.3.1	Main Steps of Startup:	61
7.4	Boiler Extreme Hot Startup	63
7.4.1	Main Steps of Startup:	64
8	Boiler Operation Adjustment.....	66
8.1	MCS Control System.....	66
8.1.1	Fuel Control System	66
8.2	Boiler Load Adjustment.....	70
8.2.1	Load Variation Rate	70
8.2.2	Coordination Control of Turbine and Boiler	70
8.3	Boiler Control Plan.....	71
8.3.1	The Conditions of Boiler Main Control Switch to Manual.....	72
8.4	Boiler Sequence Control and Interlock	72
8.4.1	The Main Protector of Boiler Interlock.....	73
8.4.2	The Subsystems of Boiler Interlock	73
8.5	Security Protection of Boiler	73
8.6	Combustion Control.....	73
8.6.1	Primary Part	73
8.6.2	Secondary Air Part.....	74
8.7	Steam Temperature Adjustment.....	74

8.8	Steam Pressure Adjustment	75
8.9	Feed Water Adjustment.....	75
8.10	Boiler Blowdown.....	76
8.10.1	Continue Blowdown Flow Control	76
8.10.2	Boiler Intermittent Blowdown.....	76
9	Shutdown and Maintenance of Boiler	76
9.1	Boiler Normal Shutdown.....	76
9.1.1	Preparation Works before Boiler Shutdown.....	76
9.1.2	Boiler Shutdown	77
9.2	Emergency Shutdown of Boiler.....	79
9.2.1	Conditions for Boiler Emergency Shutdown	79
9.2.2	Operations:.....	80
9.3	Boiler Shutdown and Maintenance.....	80
9.3.1	Purpose of Boiler Shutdown and Maintenance	80
9.3.2	Responsibility	81
9.3.3	Technical key Points for Boiler Warming up Water Discharge Vacuum Dry Method.....	82
9.3.4	Systems Received Vacuum Dry.....	82
9.3.5	Preparation Before Vacuum Dry.....	82
9.3.6	Operation Procedures.....	82
9.3.7	Inspection of Dry Effect	84
10	Accident Handling of Boiler.....	84
10.1	Accident Handling Principles.....	84
10.1.1	Accident Handling Principles.....	84
10.1.2	Key Points during Accident.....	84
10.2	Low Water Level of Boiler	85
10.2.1	Phenomena.....	85
10.2.2	Causes:	86
10.2.3	Handling:.....	86
10.3	High Water Level of Boiler	87
10.3.1	Phenomena:.....	87
10.3.2	Causes:	87
10.3.3	Handling:.....	87
10.4	Water Wall Leakage	87
10.4.1	Phenomena:.....	87
10.4.2	Causes:	88
10.4.3	Handling:.....	88
10.4.4	Prevention:	88
10.5	Leakage of Superheater and Reheater	88
10.5.1	Phenomena:.....	88
10.5.2	Causes:	89
10.5.3	Handling:.....	89
10.5.4	Prevention:	89
10.6	Combustion in Boiler Backpass	89
10.6.1	Causes:	89
10.6.2	Handling:.....	89
10.6.3	Prevention:	90
10.7	Boiler Manual Emergency Shutdown.....	90

10.7.1	Boiler Manual Emergency Shutdown.....	90
10.7.2	Specific Operation Procedures:	91
10.8	Application for Boiler Shutdown	91
10.8.1	The Definiens of Application for Boiler Shutdown	91
10.8.2	The Conditions of Application for Boiler Shutdown	92
10.9	Boiler MFT Conditions.....	92
10.10	Boiler Fire Extinguishment	93
10.10.1	Phenomena:.....	93
10.10.2	Causes:	94
10.11	One Air Preheater Trips	94
10.11.1	Phenomena:.....	94
10.11.2	Causes:	95
10.11.3	Handling:.....	95
10.12	Air preheater on Fire.....	96
10.12.1	Phenomena:.....	96
10.12.2	Causes:	96
10.12.3	Handling:.....	96
10.12.4	Measures to Prevent Air Preheater from Catching Fire	97
10.13	Sudden Load Reducing.....	97
10.13.1	Cause.....	97
10.13.2	Handing.....	98
10.14	Auxiliary Power Interruption.....	98
10.14.1	Phenomena:.....	98
10.14.2	Causes:	98
10.14.3	Handling:.....	99

Training Material of Boiler for Indian Mahan Project

1 Main Parameter and Operation Condition of Boiler

2×600mw thermal power unit boiler for India SALAYA Project is sub-critical, , controlled circulation drum, one furnace, direct burner, tangential firing boiler once-stage reheat, balance draft, solid slag remove, open, steel suspension structure, II style, drum boiler. The design fuel is bituminous coal. With the boiler maximum continuous load (namely BMCR load) as the design parameter, the details are as following.

1.1 Capacity and Main Parameter of Boiler

1.1.1 BMCR Condition

Overheat steam flow	2060t/h
Overheat steam outlet pressure	17.5MPa.g
Overheat steam outlet temperature	541°C
Reheat steam flow	1725.9t/h
Reheat steam inlet pressure	3.992MPa.g
Reheat steam outlet pressure	3.802MPa.g
Reheat steam inlet temperature	335.6°C
Reheat steam outlet temperature	541°C
Feed-water temperature	281.7°C
Boiler design pressure	19.95MPa.g
Reheater design pressure	4.471MPa.g

1.1.2 TMCR Condition

Overheat steam flow	1866.7t/h
Overheat steam outlet pressure	17.34MPa.g
Overheat steam outler temperature	541°C
Reheat steam flow	1572.7t/h
Reheat steam inlet pressure	3.633MPa.g
Reheat steam outlet pressure	3.469MPa.g

Reheat steam inlet temperature	325°C
Reheat steam outlet temperature	541°C
Feed-water temperature	275.3°C

1.2 Design Basis

1.2.1 Fuel:

Design coal and check coal of this engineer are all import coal from Indonesia

Description	Unit	Design Coal	Worst Coal
Proximate Analysis			
Fixed carbon	%	32	30
Volatile matter	%	42	40
Moisture	%	18	20
Ash	%	8	10
Grindability index	HGI	42	45
Higher heating value (HHV)	k Cal / kg	5500	5155
Ultimate Analysis			
Carbon	%	55	52.55
Hydrogen	%	4.5	4
Sulphur	%	0.4	0.5
Nitrogen	%	0.85	0.95
Oxygen	%	12	12
Moisture	%	19.5	20
Ash	%	8	10

The component analysis of typical ash is following:

Description	Unit	Value
Fe ₂ O ₃	%	24.7
CaO	%	15.1
MgO	%	7.1
K ₂ O	%	0.34
Na ₂ O ₃	%	0.08

SiO ₂	%	31.8
TiO ₂	%	0.73
Al ₂ O ₃	%	14.3
Na ₂ O	%	0.08
Sulphur (d.b.)	%	0.11
Factors		
Base / Acid Ratio		1.01
Slagging Factor		0.11
Fouling factor		0.02
Fusion Temperature		
Deformation	°C	1120
Hemispherical	°C	1187
Fluidity	°C	1208

Ignition and fuel-supporting fuel

Adopting heavy oil to support combustion, the characteristic data of oil quality as following:

Sl. No.	Particulars	Unit	Furnace Oil Grade MV2 (IS : 1593)
1	Flash point	Deg. C (min).	66
2	Viscosity @ 15°C Maxi.	Cst	180
	Viscosity @ 100°C Maxi.	Cst	
3	Pour point	°C	21
4	Ash content by weight	% max.	0.1
5	Free Water content by volume	% max.	1.0
6	Sediments by weight	% max.	0.25
7	Total sulphur by weight	% max.	4.0
8	Calcium	PPM	30.5
9	Sodium	PPM	10
10	Lead content	PPM	0.2
11	Vanadium	PPM	40.5
12	Carbon residue (Rams bottom)	% wt	7.74
13	Approximate gross calorific value	Kcal/kg	10,000

14	SP gravity at 15°C Max.		0.933
----	-------------------------	--	-------

Adopting light diesel oil to fire, the characteristic data of oil quality as following:

Sl. No.	Description	Unit	LDO
1	Code		IS:1460-1970
2	Flash point; (Pensky Martens-closed)	Deg.C	66 (min)
3	Pour Point	Deg.C	12 in winter
4	Kinematic viscosity	CST	2.5 to 15.7 at 38 Deg.C
5	Ash content by weight	%	0.02 (max)
6	Sediment by weight	%	0.10 (max)
7	Total sulphur content by weight (max)	%	1.8
8	Water content by volume (max)	%	0.25
9	Carbon residue (Rams bottom)	% wt	1.5 (max)
10	Acidity, Inorganic		Nil
11	Specific gravity at 15/15 Deg.C		0.9
12	Gross calorific value (approx)	K.cal/kcal	10, 800

1.2.2 Steam and Water of Boiler Requirements

Steam-water quality standards (According to the boiler technical agreement)

Feed water:		
PH value (25℃)	8.8～9.3（System with copper）	
	9.0～9.5（System without copper）	
Feed water		
Description	Unit	Value
Hardness	mol/L	0
Dissolved oxygen(O ₂)	g/L	≤7
Iron (Fe)	g/L	≤20
Copper (Cu)	g/L	≤5
Oil	mg/L	≤0.3
N ₂ H ₄	g/L	10～30

Conductivity (25°C)	S/cm	≤0.3
Boiler water:		
Description	Unit	Value
PH value		9~10
Hardness	mol/L	0
Total salt content	mg/L	≤20
Silica (SiO ₂)	mg/kg	≤0.25
Chloride ion	mg/L	≤1
Phosphate radical	mg/L	0.5~3
Conductivity (25°C)	S/cm	<50
Steam:		
Description	Unit	Value
Iron (Fe)	g/kg	≤20
Copper (Cu)	g/kg	≤5
Sodium (Na)	g/kg	≤10
Silica (SiO ₂)	g/kg	≤20
Conductivity (25°C)	S/cm	≤0.3

1.2.3 Classification of Construction Site is II

Zero-meter floor elevation of main power building is 10m (altitude).

1.2.4 Main Design Characteristic

- 1) The tangential firing direct burner with single furnace is used in the boiler. 6 HP1103 middle speed mills produced by Shanghai Heavy Machine Company and positive pressure direct system are arranged, the burners which are 6 floors primary air nozzle for each corner. The burner may tilt up and down with max. tilting angle 30° ; under BMCR condition, 5 mills are in operation, 1 is stand by.
- 2) The wall type radiation reheater and the big pitch superheater divided panel are arranged on the top of furnace to increase the radiation characteristic of the reheater and the superheater. Wall type radiation reheater is arranged on front wall and two side walls of upper furnace. Six big pieces of divided panel are arranged along the wide direction of furnace, to cut revolving gas flow and reduce gas temperature deviation entering the horizontal flue duct along the wide direction.

- 3) The Controlled Circulation system of rifled tube water wall is used, that might reduce the boiler circulation ratio to about 2, in order to use the low head circulating pump, reduce the electricity power consumption and improve the operation reliability; the precise water circulating calculations are done under every condition for each water wall circuit, to guarantee the reliability of the water circulation. The membrane water wall adopts the form of welding the bare tube and the flat steel.
- 4) The spacer tube and hanging tube of steam cooling are maximum used for all stages of superheaters and reheaters, to guarantee the reliability of operation. Six groups of steam cooled spacer tubes are used along the width direction between the SH divided panel and the SH platen, the guidance positioning devices are used among the SH divided panel, SH platen and wall reheater to make the localization and the clamp of the panel, prevent panel rocking in the operation; the steam cooled spacer tube crossed the furnace horizontal between the SH platen and reheater front platen to guarantee transverse space between platen, and prevent shaking in the movement; horizontal low temperature superheater in the back pass hanged and posited by the water cooling hanging tube which provided from the economizer outlet header; The metal supporting fixed is used in economizer; for the high temperature area panel (SH divided panel, SH platen, front platen of reheater), extend the most inside tube coil to clamp the bottom tube of the panel.
- 5) Based on domestic operation experience and the characteristic of design coal, the design of counter-flow heating surface uses the low gas velocity.
- 6) Bigger transverse pitches are adopted on all stages of superheater and reheater, to prevent the slag and ash plugging on the heating surface, and convenient for arranging crown-plate sealing device on the place where serpentine tube passes the ceiling, to improve the seal quality of the top of the furnace.
- 7) The larger diameter tubes are used on all stages of superheater and reheater, such as $\phi 57$, $\phi 60$, $\phi 63$ and so on. Increasing the rigidity of the tube in manufacturing and the installation is advantageous in reducing resistance of superheater and reheater; this kind of arrangement for larger diameter tubes is advantageous in reducing gas side erosion of pipes and improving erosion resistance ability.
- 8) Between all stages of superheater and reheaters, single or little quantity of big diameter connecting pipes are adopted to connect, that might play the good mixer action to the steam, and eliminate the deviation. The larger diameter tees are used on the connected place of each header and the large diameter connecting pipe.
- 9) Based on calculating the wall temperature, the resistance and flow distribution with the computer, select the material quality of superheater and reheater loop tubes; on the foundation of assuring the performance and intensity, all large diameter header and connecting pipes adopt the steel pipes according ASME standard.
- 10) Boiler is outdoor arrangement; the boiler structure completely adopts the steel structure.
- 11) Two double-tracks sealed air preheaters are equipped on each boiler. Because the moisture of the design coal

is not high and the lower drying temperature is used, the preheater uses the reversal type, to obtain higher secondary air temperature and satisfy the combustion of pulverized coal; simultaneously obtain lower primary air temperature as the desiccant.

- 12) Direct action spring type safety valves are used in boiler drum, superheater outlet and the reheater inlet and outlet. Two power control valves (PCV) are arranged in the superheater outlet to reduce movement times of safety valves.
- 13) Steam temperature adjustment mode: in order to eliminate the temperature deviation on the superheater outlet, the two-stage spray water is used for superheater. The first stage spray water desuperheater is arranged on the large diameter connecting pipe between the low temperature superheater and the divided panel, one spot each on the left and right. The second stage spray water desuperheater is arranged on the large diameter connecting pipe between the superheater SH platen and final superheater, one spot each on the left and right. The desuperheater is multi-hole tube type. The reheater temperature adjustment mainly depends on the swing of the burner, two atomize spray nozzle spray water desuperheaters are arranged on the inlet pipeline of reheater, take the use of accident spray water. The change of exceed air coefficient is useful for the temperature adjustment of superheater and reheater.
- 14) Different patterns of sootblowers are arranged in the furnace, all stages of counter-flow heating surface and the rotary air preheater, process control is used for the operation of the sootblowers, all wall sootblower and the extension sootblower should be operated every 2~4 hours according to the coal and ash condition of the heating surface. The blowing system and the process control provide by the Shanghai Clyde Bergemann Machinery Co., Ltd.
- 15) Besides calculating the intensity of boiler pressure components according to the ASME standard, the influence of intensity from the secondary stress is fully considered; analyze the stress to the main pipes and many special areas, to assure the reliability of operation.
- 16) The expansion which may carry on the precise thermal movement calculation center is equipped in boiler, takes as the basis of expansion compensation, the gap reservation and the pipe stress analysis, and is advantageous to cooperate with stress situation of every pipe which is responsible with the design institute. The design of boiler proper buckstay, the seal structure and the hanger bar are also considered. The expansion center plays an important role in assuring the boiler reliability operation and seal.
- 17) Boiler buckstay is designed according to furnace maximum instantaneous pressure $\pm 9.98\text{kPa}$. This design pressure is the furnace maximum instantaneous negative pressure taking consideration of the urgent accident of the main fuel is shutoff; the forced air fan is stop. This data conforms to the regulation of the National Fire Protection Association (NFPA). The first step of boiler horizontal buckstay arrangement is assure the

maximum permission space through stress analysis as per every position gas side design pressure, span and pipe stress; the actual space of buckstay which is assured by the door hole arrangement should be smaller than this maximum permission space. Because the both sides span of boiler horizontal duct is the biggest, in order to reduce deflection, two vertical buckstay are arranged connected with the horizontal buckstay on every side.

- 18) According to the convention, start-up drain bypass with the capacity of 5% is equipped in boiler back pass lower header. Using the bypass for drain when boiler start-up to increase the speed of superheater temperature-rising. According to the experience, this small bypass with capacity of 5% may satisfy the request of cold & hot start-up of the unit.
- 19) The boiler is equipped with furnace supervision safeguard system (FSSS) which is used for boiler start-up & shutdown, emergency trip and auxiliary shut down and put into operation. Its major function is the furnace flame examination and the furnace safe guard; it also has important significance to prevent the furnace explosion and “internal explosion”.
- 20) The coordination control system is arranged for the unit, carries on coordination control between the steam turbine and boiler. It takes the boiler and the steam turbine as a complete system to execute boiler automatic control.
- 21) The unit can operated as per not only fixed pressure operation but also sliding pressure operation. When the boiler operates and starts-up on low load, the sliding pressure operation is recommended, to obtain higher economy.

1.2.5 Account Data Table of Prospective Function for Boiler

Name	Unit	BMCR	TMCR	80%TMCRsetting pressure
Main steam flow	t/h	2060	1866.7	1448.3
Main steam outlet pressure	MPa.g	17.50	17.34	17.04
Main steam outlet temperature	℃	541	541	541
Overheat steam pressure drop	MPa	1.5	1.250	0.782
Feed-water pressure	MPa.g	19.492	18.95	18.19
Feed-water temperature	℃	281.7	275.3	259.7
Reheat steam flow	t/h	1725.9	1572.7	1237.8
Reheat steam outlet pressure	MPa.g	3.802	3.469	2.720
Reheat steam outlet temperature	℃	541	541	541
Reheat steam inlet pressure	MPa.g	3.992	3.633	2.849

Reheat steam pressure drop	MPa	0.19	0.173	0.136
Reheat steam inlet temperature	°C	335.6	325	305.4
Air heater inlet primary air temperature	°C	34	34	34
Air heater inlet secondary air temperature	°C	31	31	31
Air heater inlet flue gas temperature	°C	366	357	340
Air heater outlet primary air temperature	°C	338.9	333.9	318.3
Air heater outlet secondary air temperature	°C	347.8	341.1	324.4
Air heater outlet flue gas temperature not adjusted	°C	140	139	125
Air heater outlet flue gas temperature adjusted	°C	135	133	120
Grinder inlet air temperature	°C	232	222	223
Economizer outlet overair coefficient		1.2	1.2	1.2
Coal burning quantity	t/h	261.3	241.9	195.2
Boiler efficiency (By gross calorific value)	%	87.8	87.79	87.9

The condition of overheat steam temperature and reheat steam temperature reach the rated value as following:

Constant pressure operation: 50~100%BMCR

Sliding pressure operation: 50~100%BMCR

Boiler guarantee value is determined according to design fuel data and boiler design working condition.

2 Boiler Body

2.1 Drum

The drum is made from carbon steel material of SA-299, the inner diameter is $\phi 1778\text{mm}$ (70"), the total straight section length is 25756mm; sphere headers are used on both sides. Different wall thicknesses are adopted for the upper and lower shell, the upper shell thickness is 182mm, the lower part shell thickness is 153mm. the ring-like

sandwich structure used in the inner drum as the pass of steam water mixture make the wall temperature of drum upper and lower parts uniform, that may increase the speed of boiler start-up and shutdown. 112 cyclone separators with the diameter of $\Phi 254\text{mm}$ are arranged in the drum internal, maximum output of each separator is 18.10t/h (18.39t/h).

The saturated steam discharge pipes socket and steam water mixture inducing pipes socket, vent valve pipes socket and assistant steam pipes socket are welded on the top of the drum shell; big diameter downcomer socket and feedwater tubes socket are welded on the bottom of the drum shell; man hole, safety valve discharge pipes socket, continuous blowdown pipes socket, high & low water level pipes socket, liquid level sampling pipe socket and experiment jointment pipes socket are welded on the head.

The drum internal equipment, the water level measured device

2.1.1 The Drum Internal Equipment

The function of drum internal equipment is separate the water from the steam produced in the water wall, and reduce the salinity content in steam below the standard. Usually, the steam water separation includes three stages, the first two separations complete in the cyclone separator, the third separation is completed in the top of drum before the steam enters into the saturated steam discharge tubes.

The steam water mixture produced in the water wall enter the top of drum (W—9) through steam water discharge pipes (W—31) (see drawing 01—03 the Boiler Feed Water and Water Circulation System Arrangement Chart), along the whole length of drum, through the narrow channel formed by dampers , flows off from the both sides. Because dampers and drum shell are concentric, there is invariable speed and heat-transfer rate when steam water mixture pass through, in order to keep the same temperature on the drum surface. On the damper bottom edge, steam water mixture flow upgrade into the two lines of cyclone separator.

Do the secondary separation in the cyclone separator.

The first separation is produced between two concentric cylinders. When the steam water mixture flows upgrade into the inner cylinder of cyclone separator, there is centrifugal circumgyrating movement with the function of diversion blade, it makes the heavier water flows upgrade along the inner cylinder wall, meet the division bend plates on the top of the inner cylinder and circumgyrates down, through the pass way between the two cylinders return to the drum water space. Separated steam flows upgrade continuous to carry out the second separation.

The secondary separation executes in two groups of close arranged corrugated thin steel plates in the top of the cyclone separator. When steam pass through twist way between the thin steel plates, because of the effect of inertia, the water in the steam hit on the corrugated plates. Simultaneity, because the speed of steam is not high, the water cannot be drove again. Separated water flows down along the corrugated thin steel plates, drops along the edge of

the corrugated thin steel plates at the steam outlet.

After the second separation, the steam flows up to execute the third namely the last separation. Several lines of corrugated dryer screen are arranged on the top of drum along the direction of drum length, drain pipes are set among the lines, when steam through the twist way between the bend plates of the jalousie on lower speed, the taken remnants water may sediment on the corrugated thin steel plates, it cannot be taken again by the steam, but flows to the drain pipe along the corrugated thin steel plates, return to the drum water place through the tubes.

2.1.2 Control Value of Drum Level

Normal level	229mm lower than drum central line229mm	
Allowable punctuating value of level:	Normal level $\pm$ 50mm	
Alarm level:	Normal level	+127mm
		-178mm
Shutdown level:	Normal level	+254mm
		-381mm

2.2 Economizer

2.2.1 Structure Instruction

The function of economizer is to heat the feedwater, so heat can be recovered from the gas leaving the boiler.

Economizer is laid in the lower part of back pass duct, tube diameter: $\Phi 51 \times 6.5$, with 135 pieces of in-line arrangement horizontal tube coil as the boiler width. All the serpentine tubes come from inlet header (W-1), and finally go to outlet header (W-3) (Refer to drawing 01-03 《arrangement drawing of feedwater and circulation system》).

Feedwater goes into entrance piping of economizer through economizer check valve (V-1) and economizer gate valve (V-2), and then into tube bank through economizer inlet header. Water and gas in the tube bank flow in an up-countercurrent way to keep efficient heat exchange, at the same time decrease the possibility of stagnation caused by air bubble in the tube bank. The feedwater heated in eco. will enter into inlet header of eco. and pass through water-cooling hanger tube to outlet header of water-cooling hanger tube, then pass through outlet piping to the drum.

Economizer recirculating piping (W-32) is connected with economizer entrance header (W-1) end and lower header of rear water wall (W-18). The recirculating piping can lead boiler water to economizer to protect the water in the economizer from boiling during start-up. During start-up the valves in the recirculating pipe line can't be

closed until boiler water is continually supplied.

1) Maintenance

- a) Before start-up and during shutdown, the appearance of economizer should be examined and cleaned if necessary. The newly-installed boiler usually has certain amount of residuum (wood block, heat-insulating material, welding rod head, etc.), so scattered residuum can be manually got rid of, then tubes in economizer can be flushed with water.
- b) Appearance of heat-insulating material should be in a perfect state
- c) The access door should be tightened with bolt, and the seal condition of it should be usually inspected.
- d) If sootblower is installed, the using times of it depends on the actual circumstances of economizer. Economizer should be purged once in each shift during initial operation. Blowing period depends on the resistance changes of gas. Under most circumstances, it is adequate to purge the economizer once everyday.

2.3 Furnace and Water Wall

Furnace is space organized fuel burning in the boiler, also called combustion chamber, is an important part of boiler combustion equipment. Furnace besides changes chemical energy of fuel into heat energy of combustion products, undertakes the task of organizing furnace heat transfer, therefore, the structure can guarantee fuel burn completely, and the flue gas at furnace outlet has been cooled to the allowable temperature makes rear convective heating surface work safely.

Water wall is evaporating surface consists of many paralleling pipes lying around furnace. The main functions are: absorb radiating heat of high temperature flame and furnace flue gas in furnace, to make water vaporize in water wall and produce saturated steam; reduce damage from high temperature to furnace wall, to protect furnace wall; intensify heat transfer, reduce boiler heating surface area, save matel consumption; effectively prevent the furnace wall slagging; and suspend furnace wall.

The furnace water wall of boiler adopts welding diaphragm wall, sectional dimensions of furnace are 22187mm×15632mm.

The boiler furnace and water wall design data

Furnace section (furnace width, furnace depth)	mm
Furnace volume	m ³
Furnace water wall area	m ²
Distance from upper primary air centre line to panel bottom	m

Furnace volumetric heat load	kW/m^3	
Furnace section heat load	MW/m^2	
Burner area wall heat load	MW/m^2	
Furnace effective projective radiation heating surface heat load	kW/m^2	
Furnace outlet flue gas temperature	$^{\circ}\text{C}$	
Flue gas temperature of screen superheater bottom	$^{\circ}\text{C}$	
Remark: the data will be filled with further information		

Water Wall

Membrane water wall structure

The water wall is constructed by tubes with $\Phi 50.8\text{mm}/\Phi 51\text{mm}$ outside diameter and 63.5mm pitch. The gap between the tubes is welded by flat steel to achieve complete seal for gas.

Furnace arch nose is constructed by tubes with $\Phi 63.5\text{mm}$ outside diameter and 76.2mm pitch. The gap between the tubes is welded by flat bar.

Furnace extended side wall is constructed by the tubes which outside diameter is $\Phi 63\text{mm}$ and are welded by solid fin as per pitch of 127mm.

Upper furnace roof tubes are constructed by the tubes which outside diameter are $\Phi 63\backslash 57\text{mm}$ and are welded by peg fin as per pitch of 127mm.

After the installation of peg fin, refractory concrete should be poured into back side and put sealing plate on it. The joining parts of sealing plate should take seal weld to prevent gas leakage.

Perforate on hanger tubes and the SH components which formed by tubes bending to the outside. Such as observation holes and sootblowing holes, the gap between tubes and holes should be welded by fins to form a complete metal surface for gas.

Insulating material should be poured to every level of horizontal buckstay to form a continuous insulant shroud wing of furnace to prevent gas leaking from the gap of casing and water wall. Heat insulating material should be filled in vertical buckstay and corner.

Furnace water wall、horizontal duct and back pass furnace wall are formed by heat insulating materials. Insulating materials are fastened by the studs welded on back side of water wall and the place of corner is fastened by steel wire net. The outside furnace wall is covered by trapeziform corrugated galvanized outer casing.

The details of furnace wall are shown in furnace wall arrangement drawing and typical structure drawing.

Furnace Hopper

The type of furnace hopper is decided by the kind of fuel and the character of ash. The boiler adopts open furnace hopper. The furnace front and rear water wall falling inclined of furnace center to form hopper slanting bottom.

Passing the bottom opening directly the ash will fall down to ash hopper from furnace. Enough clearance between furnace and ash hopper should be preserved according to the height of furnace, water-seal device or mechanical seal device (expansion joint) is installed here to prevent air from entering.

Water Wall Operation

1) Tube scale

Because design heat release rate of water-cooled furnace is usually high, special attention should be paid to avoid scaling and Cu/Fe oxide depositing inside the water wall tubes. To achieve this, the quality of boiler water feed water should be guaranteed.

Scale is the insulating film precipitate cohering in tube inside wall, which could cause the temperature of tube fireside surface metal wall to increase and make the tube overheating. To avoid scale, unscaled ingredient should be used instead of scaled ingredient of feed water during the water treatment.

In high pressure boiler, the Cu/Fe oxide brought by feed water system could cause erosion at its precipitated place and damage the tube. To avoid this erosion, the ingredient which could control erosion should be put into feed water system during the water treatment.

Doing acid cleaning before putting the boiler into operation could make the inside parts of heating surface clean. After a long time operation of the boiler, especially when the condition of boiler water is abnormal, having scale and oxide deposition, acid cleaning should also be done.

2) Blowdown

Blowdown is a method of controlling the density (solid matter and alkalinity) of boiler water and blowing down the sludge precipitate. Times of blowdown is decided by the boiler condition, such as characteristic of water quality, effect of water treatment, design feature of boiler and boiler capacity. Under most circs, using continuous blowdown of the drum is enough.

If there is special condition of making sludge precipitate or bringing salinity which caused by poor effect of water treatment and salinity content is high, blowdown could be done from periodic blowdown pipeline of the back water wall lower header. Times of periodic blowdown are usually once a shift or 24 hours once, under special circumstance it could be decided by water quality.

DN125 discharge valve is installed on front water wall lower header, it could be used for blowing off only after boiler shutdown and must not be used for emergent blowing off in normal operation or used for blowdown.

Regulations of other ingredients such as total molten-salt and alkalinity should not be ignored at any time or exceed regulated value. Times and quantity of blowdown should conform to regulations of chemical subsidiary or other governors, but correct or not of water treatment and salinity control is finally lie on operating personnel.

3) Ash Plugging (slagging)

The quantity and velocity of slagging is lie on the characteristic of fuel. It is impossible that there is no ash plugging and slagging on water wall surface, but it must maintain within a reasonable scope (see the note). Using the soot blowing device correctly can avoid serious local slagging, but it should be used to necessary place not unselectly.

Note: When the first time of boiler operation, steam temperature is lower than design value because furnace water wall surface is very clean and heat absorption of furnace is bigger than design value. The time to reach normal pollution of furnace is called “aging time”. All coal fired boilers and high-ash fuel oil fired boilers have this aging time, and it changes with the kind of fuel (ash content and ash characteristic). Furnace is getting polluted during operation and that makes furnace outlet gas temperature increase gradually, and cause steam outlet temperature increase. If let the condition going on steam outlet temperature may exceeds the control value, wall sootblower should be used at this time to make the steam outlet temperature decline to a control range.

When changing the fuel, such as from coal to oil or from oil to coal especially using substitute fuel for a long time, soot blowing system should be used to clean the furnace completely. If foresee from the experience of changing oil to coal that serious slagging is possible to occur because of the change of fuel character, a full purge for furnace is very necessary before putting into operation.

Maintenance

Inspection

Inspect furnace water wall tubes、drum and header after every time boil-out、first time acid cleaning、routine acid cleaning and annual boiler shutdown.

When inspecting open header handhole and drum manhole, check if there is any deposit on the surface of equipments inside the drum. Spot-check the tube to see if there is any scale inside the tube from tube end. If there is, removal work should be done then wash the tube、header and drum by pure water.

Inspect water wall outer surface to see if there is any expansion、ablation、erosion and crack (see the note). To achieve inspection purpose, ash on the fireside surface of furnace tube should be removed in advance.

Note: tubes around sootblower are easy to be corroded.

Coal fired boiler needs checking the assembly and operation of furnace hopper soot blowing system before putting into operation to see if it meets the requirements. If cool water is possible to spurt onto water wall tubes under the condition of normal operation or abnormal operation, it is necessary to correct it.

All inspection contents including details should have no pretermision. And it should be inspected by the person who is very familiar with boiler operation and maintenance as well as water treatment. Fill the inspection record and save it as per regulations so that it is easy to compare with former record when inspecting result has changes.

The inspecting result such as tube damage and its reason should be recorded in details. If the reason of damage is

not obvious or could not be affirmed easily, the inspecting content should be enlarged, for example, take metallographic examination to tube section and take chemical analysis to scale.

Tube Repairing

The damaged parts of tube or the parts which must be changed for having possibility to be damaged are commonly to be replaced. Firstly, remove furnace insulation behind the damaged parts, then transversely cut the damaged parts and should cut enough length of the damaged parts from up and down. Cut the fin carefully along the direction of tube length (see the note), insert new tube and weld it after the repairing of tube end groove.

Remark: Longitudinal cutting of fin must exceed a certain length of tube crater, after new tubes installed to have enough room for complete welding around crater. After tubes welding finished, should re-put fins into the tubes and re-make seal welding.

Manhole、soot blower hole、instrument measuring hole of flue gas and air system

Manhole、soot blower hole、instrument measuring hole of flue gas and air system. Manhole、soot-blowing hole and measuring hole are necessary for boiler, which provide convenience to operation、maintenance and adjustment, and should be installed in suitable place as per their different use to meet requirements.

Install one water cooling large access door which size is 610×762 mm for each on two sides of water wall in the bottom of furnace hopper, and could be used for slag removing at slag notch of furnace hopper. Following parameters should be kept during operating for cooling water, inlet temperature is 38°C, inlet pressure is 4.5kg/cm², outlet temperature is 54°C, water flow is 1m³/h. The boiler has various manholes, television ports, soot blower holes, furnace outlet gas temperature probes and instrument measuring holes. To avoid gas leakage and ensure the gas tightness of boiler, all holes are equipped with seal boxes.

Boiler Circulation Pump

Three sets Wet motor boiler circulation pump made by Germany KSB Company

Model No.: LUVAc 2x350-500/1 + Motor 6/4 IV 40-605

Before drum steam pressure reached 0.689MPa start up the third circulation pump to reduce temperature gradient bore by circulation pump shell. When boiler with full load should put three pumps into operation, to support greater load adjustment flexibility and avoid the possibility of load shedding causes by one of the circulation pumps emergency shutdown pump when two circulating pumps operation.

2.4 Superheater and Reheater

2.4.1 Superheater

SH is composed of five main parts: a) final SH (S-37); b) SH platen (S-31); c) divided panel SH (S-27); d) low

temp. SH pend (S-21) and horizontal low temp. SH (S-20); e) roof SH and back pass cage wall system (S-5, S-7, S-8, S-9, S-13, S-16).

Final SH lies in the horizontal duct which is located at the back of the rear water wall tube screen, with 96 pieces, diameter: $\Phi 57$, laid along the whole boiler width with transverse pitch: 190.5mm.

SH platen locates before the arch nose of furnace, with 32 pieces, diameter: $\Phi 57$, $\Phi 51$ laid along the whole boiler width with transverse pitch: 571.5mm.

SH divided panel (S-27) is located in the upper furnace between front water wall and SH platen, lay along the boiler width with six large pieces, each of which has eight small pieces along boiler depth. It is laid along boiler width with transverse pitch 2286mm and 3048mm respectively from the boiler centre, diameter: $\Phi 51$.

Vertical low temp: SH (S-21) lies in the reversing chamber of back pass, above the horizontal low temp. SH, with 120 pieces, diameter: $\Phi 63$, laid along boiler width with transverse pitch 153mm.

Horizontal low temp: SH (S-20) is located above the back pass economizer, with 120 pieces, diameter: $\Phi 57$, laid along boiler width with transverse pitch 153mm.

Roof SH and back pass cage wall system are composed of roof tubes (S—5) (S—7)、sidewall (S-13)、front wall (S-9)、rear wall (S-8) and back pass extended cage wall. It forms a vertical downcomer duct; back pass extended cage wall forms a part of horizontal duct.

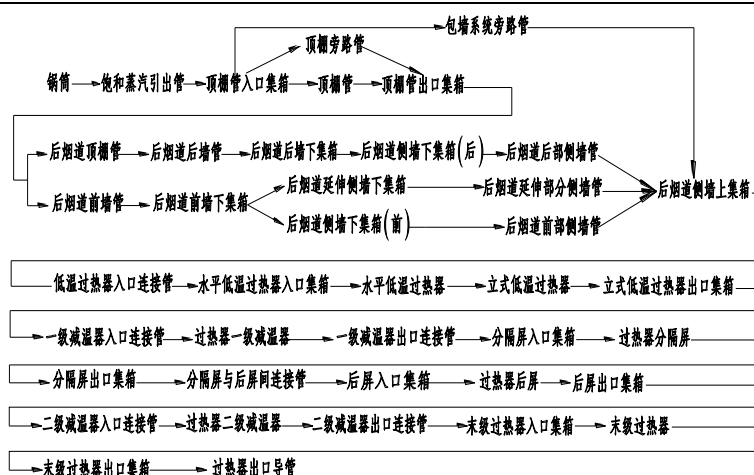
Basic regulation of correct operation regulation for superheater drain valve and vent valve

Complete drainage should be made to back pass cage wall tube and main steam connecting piping (especially after hydraulic test). For this, drain valves of each entrance and exit headers and vent valves should be opened before ignition. After drainage is finished, the entrance and exit header drain valves are closed to a small opening. The vent valves should be closed when steam comes out of them on the connecting pipelines. Drain valves in each header of backpass are promptly closed after turbine roll. Other specifications refer to 《Boiler operation》.

The drain valve and vent valve on the main steam pipes are used to exhaust steam during start-up. Open these valves during start-up and should close them until turbine goes with part load. During start-up, with the rising of drum pressure these valves function as throttling cock to keep efficient steam flow through SH. (See start-up section in 《Boiler operation》) during start-up, vent valves in other headers and connecting pipelines should be completely opened until boiler pressure increase to approximately 1.75kg/cm². The drain valves near turbine should also be completely opened, and used together with vent valve for certain amount of steam flow through pipelines, functioning as drainage and warming pipe before turbine rolling.

Flow of overheat steam and reheat steam can be displayed in attached diagram as following:

Overheater system flow



2.4.2 Reheater

RH is mainly composed of three parts: a) final RH (R-12); b) RH front panel (R-10); c) Wall radiant RH (R-4) (R-5).

Final RH (R-12) is located in the horizontal duct at the back of furnace arch nose, between rear wall hanging tube and water wall tube screen, totally 72 pieces, diameter: $\Phi 63$, laid along boiler width with transverse pitch 254mm.

RH front panel (R-10) is located between SH platen and hanging tube of rear water wall, on the upper part of arch nose, totally 48 pieces, diameter: $\Phi 63$, laid along the boiler width with transverse pitch 381mm.

Wall radiant RH (R-4) (R-5) is located between the front wall and side wall of water wall and close to front wall, with the height to be one third of furnace. Front wall radiant RH has 256 tubes ($\Phi 60\text{mm}$), side wall radiant RH has 260 tubes ($\Phi 60\text{mm}$), arranged tightly along the water wall surface with pitch: 63.5mm.

Basic provisions with correct operation for reheater drain valve and vent valve

Before ignition, open all drain valves and vent valves. Before condenser starts to bring the vacuum, close drain valves and vent valves which are led to the atmosphere. The drain valves connected with condenser can still be open until turbine brings low load.

After turbine high pressure cylinder worked, steam led to boiler from cold-end reheater tubes, and flows into reheater system. Reheater and attemperator lies on cold-end reheater tubes. Reheater system flow as following:

Attention: The following construction of steam cooled spacer is used for keeping the transverse pitch of SH and RH tube bank and to protect from shaking:

- 1) Steam cooled spacer is used to keep the transverse pitch of divided panel, to protect panel from excess deflection, the flow chart is as follows:

Divided panel entrance header (S-26) → entrance tube of steam cooled spacer (S-40) → steam cooled clamp spacer (S-41) → exit tube of steam cooled spacer (S-42) → exit header of SH platen (S-32).

- 2) Steam cooled spacer is used to keep the transverse pitch of SH platen and RH front panel, to protect SH platen

and RH front panel from excess deflection, the flow chart is as follows

Entrance connecting tube of back pass extended cage wall (S-14) → steam cooled spacer (S-43) and (S-44) → entrance header of SH platen (S-30).

2.4.3 Superheater and Reheater Protection and Control

The element of SH and RH should be protected if there is combustion condition in furnace. Especially under the circumstances of no steam flow in the element, for example, because of no steam flow during start-up and shutdown, drainage and exhaust steam of pipeline and main steam pipe should be connected to keep small amount of steam through SH element. During ignition the residual moisture in the RH element can be evaporated in the ways of drain and exhaust steam.

The setting pressure of safety valve in the SH outlet steam pipe is lower than the smallest setting pressure of safety valve in the drum. When steam flow in the main steam pipe accidentally decreases, first open safety valve in the main steam pipe for certain amount of steam to go through and protect the SH. Safety valves are installed in the cold end and hot end pipelines of RH, which can act when steam flow in the RH steam pipe of RH accidentally decreases to protect the RH. Power discharge valve is installed in the main steam pipe of SH, the setting pressure of the power discharge valve is lower than all of other safety valves, thus the valve can act first to alarm in advance when steam pressure is higher than allowable pressure. Discharge flow of power discharge valve isn't included in the total discharge flow of boiler safety valve according to the specification.

Special attention should be paid to not make pipes of SH and RH overheated during start-up. Fuel amount should be controlled so that outlet gas temperature of low furnace is lower than 538°C. Two retractable gas probes are installed in the upper part of furnace side wall to measure outlet gas temperature.

Note:

- 1) The gas temperature is more exact if measured with gas extractable thermal couple with enclosure. If adopt bare thermal couple the reading will be more lower because radiation could cause heat deviation. When gas temperature is 538°C, the reading of thermocouple is about 28°C lower.
- 2) 538°C furnace exit gas temperature is based on normal start-up condition. At the same time turbine can be rolled under minimum pressure stipulated by factory. If turbine delays the rolling, steam pressure continually increases, and steam exceeds two thirds of design pressure before going into turbine, under this condition, the limit of furnace exit gas temperature will be reduced to 510°C.
- 3) The element tubes of SH and RH install thermocouple on the part where above the roof tube, so that continuous measurement can be done to SH、RH and metal wall temperature of each element tubes when start-up and units with load. The place of thermocouple showed in arrangement drawing of metal temperature

measuring points.

This unit installs turbine bypass system, which is used in cold、hot start-up and run back to protect the RH and recover condensing water.

2.4.4 Desuperheated Water System of Superheater and Reheater

Desuperheaters are arranged in the SH connecting piping and RH entrance cold end piping, it is necessary to control the steam temperature at a designed value.

Process of desuperheater is as follows: at the desuperheater entrance end the desuperheated water is sprayed into steam through nozzle for temperature drop. The spray water comes from feedwater system. The spray water must be clean and can't include suspended solids and soluble salt (can include organism volatile constituent according to specification) to prevent salt sediment in the SH and RH or into turbine.

Note: during start-up, if steam entrance temperature is suitable to turbine metal wall temperature by using spray attemperation, steam temperature after spraying should be 6°C higher than saturation temperature. During start-up, because of low steam flow and less efficient desuperheater spraying, and sometimes spray can't completely be vaporized, and then is brought by steam through each components into turbine, which can possibly causes great losses. So during start-up other attemperating measures should be used.

SH Desuperheater

SH desuperheater has two stages arrangement with the quantity of four . The primary is arranged on the connecting pipings between exit header of vertical low temperature SH and entrance header of division panel, with each one on right and left sides. The secondary is arranged on the connecting pipings between exit header of SH platen and entrance header of final SH, with each one on right and left sides.

RH Desuperheaters

Two RH desuperheaters are arranged on the cold end RH.

Operation Platform of Desuperheated Water

The injection flow of each desuperheater is controlled by control valve with auto-control actuating device. Electric shutoff valve and pneumatic lock valve are arranged on the two ends of control valve. The control valve can be separated if necessary. The drainage valve under control valve can be used for system pressure relief and for drainage of pipeline during maintenance of control valve.

The lock valve on the water supply pipeline of each operation desk of attemperation water is used as additional shutoff valve. These lock valves must be interlock closed when close the spray regulating valve. Spray control valve should be interlock closed during cut-out of turbine. The aims of lock valve are to prevent spray through cold end reheating piping from entering into turbine when RH spray control valve is leaking, and to prevent spray from

entering into SH element when SH spray control valve is leaking.

Maintenance

The internal sleeve is arranged in the desuperheater. Internal sleeve bears the corrosion of spray and steam to protect desuperheater shell. The internal sleeve can be replaced after damage. Too much noise in the desuperheater indicates that internal sleeve has been corroded. Replacement of internal sleeve should be consulted with the factory. There should be enough place near desuperheater during installation for the convenience of replacement of internal sleeve.

2.4.5 Superheater and Reheater Operation Maintenance and Inspection

1) Maintenance

It is very important to keep the inside and outside of SH and RH clean at any time. Fly ash and slag collecting in the outside surface will cause asymmetric distribution, reduction of heat-transfer and local overheating. Making good use of sootblower and appropriate purge period is to keep the outside of heating furnace clean.

The outside surface of SH and RH should be checked periodically. Making full use of sootblower can reduce slagging at minimum, but still causes local slagging. Overlarge slagging collection must be removed once found. Local slagging can cause overheat and damage of tubes, and obstruction of gas flow and asymmetric heat transverse, which will make the operation difficult.

Dealing with the feedwater and control of steam quality are the basic measures to keep the inside of SH clean. Overload, load variation, higher water level, bubbles and high concentration all can cause surface sediment. Collection of inside sediment can cause damage of tubes. This boiler uses spray desuperheater with condensing water to avoid salt stay in SH, RH and turbine blade. The changes of steam head loss can usually reflect if there is salt sediment in the element. The steam press.drop of SH, RH systems should be checked periodically under the same stable load.

Reasons should be carefully found if there are accidents of element. The manufacturing factory should help to recommend remedy scheme and measures to avoid accidents.

2) Checking

Specifications of relative checking and maintenance should be carried out carefully to guaranty the continuous unit operation, to avoid shutdown accident of great economic losses.

- a) SH and RH should be checked during shutdown.
- b) Check if element arrangement is in order, if there is contortion and expansion in the tube. Replace the severe contortive, overfired tubes with expansion.
- c) Check the support of element, the position of pipe clip and seal plate and the condition, promptly repair and

replace damage component.

- d) Check the inside and surface of the drum. If salt is found, find the reason and take measures immediately.

2.5 Soot Blowing System, Flue Gas Temperature Probe

2.5.1 Soot Blowing System

Overheat steam reduced pressure through pressure reduction station and provided for scavenge by retractable sootblower, furnace sootblower and air preheater sootblower, retractable sootblower and furnace sootblower come from influent header of reheater on boiler proper back screen, parameters of steam source are $p=4.5\text{MPa}$, $T=383^{\circ}\text{C}$, pressure reduction station will adjust pressure and flow to meet scavenge requirement for sootblower.

Electric drain valve according to temperature signal control startup of pipe drainage and maintain pipe drainage in normal operation.

Auxiliary steam source station uses steam comes from starting up boiler only when boiler startup or compressed air provided scavenge for air preheater sootblower.

Operation of Sootblower

A sootblower can be regarded as a part of a large sootblowing system. The system includes pipe, steam source stop valve and drain equipment, sootblower and control system. Control system controlled the sootblowing process, including pressure monitoring, temperature lock and scavenging time of scavenging medium, protective boiler and sootblower. Sootblower operated usually by switch cabinet and control panel. See control system document for details.

Scavenging Frequency and Scavenging Pressure

Scavenging frequency depends on how much time and dust deposit on heating surface. After boiler primary startup, must regularly visual the condition of heating surface in the scope of scavenge, if the cleanness effect is not so good, should improve scavenging frequency and scavenging pressure. With the same measurable indicators, i.e. if no scavenge, the flue gas temperature and draft difference of boiler will reach a certain unacceptable degree. Scavenge airflow of sootblower can efficiently clean dust deposit in furnace, so it is absolutely necessary to regularly control the cleanness of heating surface. If the pipe surface of heating surface appears smooth and lightspot, scavenging frequency and scavenging pressure must be reduced.

Operation in Long-time Disconnection

Sootblower operated regularly can maintain its functions; if no usage or little usage, the sootblower should be operated once a week to make the moving parts, especially limiting CB in good working conditions.

Faults in Operation

- 1) If sootblower operation has mechanical faults, over-current relay of sootblower will be closed, and the power source of motor lost. Meanwhile, nozzle will return to the position of stop immediately, and terminal limiting CB will close motor power supply when nozzle reached the position of stop.
- 2) If steam pressure reduced to rated value below, pressure controller acts to make sootblower immediately return to initial position.
- 3) If sootblower electric control malfunctioned, or motor coil damaged, the handle must be inserted into the shaft of motor rear, manually return sootblower to position of stop. Before the operation, power source of motor should be confirmed to be close and cannot connect again.

Cooling of Nozzle

When scavenge, nozzle must be cooled by scavenging medium to prevent overheating. Sootblower can be operated only when the pressure reached minimal scavenging pressure (generally be 0.7MPa) of nozzle cooled. Pressure control is measured on valves of sootblower by pressure gauge. The pressure gauge is installed on pipe of sootblower, and operated by safety CB of electric pressure. When setting minimal pressure value has not been set, the switch controlling sootblower cannot be operated. When scavenging pressure declined to setting minimal pressure below, the sootblower will immediately stop scavenge and return to the position of stop. After pressure rose again to normal value, sootblower will restart to work.

2.5.2 Flue Gas Temperature Probe

Temperature probe generally is applied to critical area of boiler overheater or reheater inlet to prevent overheating of pipe wall metal during boiler startup. Temperature probe consists of a gun barrel with exploring component inside. With the help of walking tank, the gun barrel stretched into or out furnace to measure flue gas temperature of furnace along boiler width.

To measure flue gas temperature of each point in furnace, the design of control system enable to stop temperature probe at each reserved position in the process. And thermocouple terminal is displayed at the position of furnace inside by position indicator.

Operation

Local operation

- 1) Close power supply, indicator of “power supply” to emit light on local control box.
- 2) Set option switch to be local control.
- 3) Press button of ‘forward’, motor startup, gun barrel acts forward, and indicator ‘operation’ on.
- 4) When temperature measured is lower than setting alarm temperature (540℃), the gun barrel will continual action upward till:

- a) Back up the action of travel switch RLS, which will cause gun barrel operation in reverse automatically.
 - b) Operator presses button 'back', which will cause gun barrel operation in reverse immediately at any position of the process.
 - c) Operator presses button 'stop', which will cause gun barrel operation stopped immediately at any position of the process, in order to make temperature probe to monitor the temperature of point continuously.
 - d) Operator presses button 'stop/reset', which will cause gun barrel operation in reverse immediately at any position of the process until backs to stop position and then stopped work.
- 5) When local operation, instruments in central control room display the glue gas temperature measured and the position of gun barrel terminal.
- 6) When gun barrel operates forward or stopped operation, press button 'back' will cause gun barrel operation in reverse until:
- a) Stop the action of travel switch SLS, which will cause gun barrel operation turn to forward automatically.
 - b) Operator presses button of 'forward', which will cause gun barrel immediately change the operation from backward to forward at any position of the process.
 - c) Operator presses button of 'stop', which will cause gun barrel operation stopped immediately at any position of the process, in order to make temperature probe to monitor the temperature of point continuously.
- 7) When gun barrel operation forward or in reverse, or when gun barrel operation stopped, press button 'stop/reset' will cause gun barrel back to stop position.
- 8) When the temperature of furnace flue gas measured by temperature probe reached or exceeded setting alarm temperature (580°C), gun barrel will automatically back to stop position and send out alarm signal of 'high flue gas temperature'.

Remote operation

- 1) Close power supply, indicator of "power supply" to emit light on local control box.
- 2) Set option switch to remote operation on local control box.
- 3) Press button 'forward', motor started up, gun barrel operated forward, and indicator 'operation' emitted light.
- 4) When temperature measured is lower than setting alarm temperature, the gun barrel operation forward continually until:
 - a) Back up the action of travel switch RLS, which will cause gun barrel operation in reverse automatically.
 - b) Operator presses button 'back', which will cause gun barrel operation in reverse immediately at any position of the process.
 - c) Operator presses button 'stop', which will cause gun barrel operation stopped immediately at any

position of the process, in order to make temperature probe to monitor the temperature of point continuously.

- 5) Operator presses button 'stop/reset', which will cause gun barrel operation in reverse at any position of the process, until back to stop position and stop operation.
- 6) When remote operation, instruments in central control room display the glue gas temperature measured and the position of gun barrel terminal.
- 7) When gun barrel operates forward or stopped operation, press button 'back' will cause gun barrel operation in reverse until:
 - a) Stop the action of travel switch SLS, which will cause gun barrel operation turn to forward automatically.
 - b) Operator presses button of 'forward', which will cause gun barrel immediately change the operation from backward to forward at any position of the process.
 - c) Operator presses button 'stop', which will cause gun barrel operation stopped immediately at any position of the process, in order to make temperature probe to monitor the temperature of point continuously.
- 8) When gun barrel operation forward or in reverse, or when gun barrel operation stopped, press button 'stop/reset' will cause gun barrel back to stop position.
- 9) When the temperature of furnace flue gas measured by temperature probe reached or exceeded setting alarm temperature, gun barrel will automatically back to stop position and send out alarm signal of 'high flue gas temperature'.

Probe operation in long-term outage

Under general condition, the probe operates frequently, therefore the operation capacity is guaranteed in any time.

But if rare operation, the operation should be took at least once every 14 days, to guarantee the action ability of moving parts especially limiting switch.

2.6 Safety Valve

In the project, drum sets six safety valves with Model HE-96W, overheater outlet sets two safety valves with Model HCI-88W and two PCV valves with Model EOL121N7BWRA5P1, overheater inlet sets seven safety valves with Model HCI-46W, reheater outlet sets two safety valves with Model HCI-38W.

2.7 Boiler Circulation Pump

Boiler unit water circulation system is designed by two of three boiler circulation pumps put into operation with

full load. In order to increase operational flexibility, boiler can be operated with three pumps. If only one pump put into operation, boiler load must be reduced to 60% of MCR (Maximum Continuous Rating). If continuous load is lower than 60% of MCR, allowable to put single pump into operation. When all pumps disconnected, boiler is unallowable to work. Meanwhile, main fuel trip which is interlocked with pressure difference measuring instrument of circulation pump plays a role of protection. When startup, suggest to put at least two pumps into operation.

Boiler unit equipped with boiler circulation pump of wet motor LUVAC350□2—500/1 made by Shenyang turbine machinery Co., Ltd., the pump is invert type (motor is put under the pump). Circulation pump is designed for guaranteeing boiler water circulation.

Control circulation boiler in the state of startup cooling (boiler water temperature between 93°C and 121°C), if not implement specified operation regulation, the rotating parts of circulation pump will cause violent vibration.

Note:

Operation under the condition of violent vibration for long term, will cause damage of bearing and pump blade; if instrument occurs time response, the vibration can be detected by fluctuations of motor current amperage.

2.7.1 Air Carryover

The design of invert boiler circulation pump has greatly decreased the hazard stored air in pump, nevertheless must pay attention to take reliable measures to prevent air gaps existed in pump. Due to small clearance between bearing and motor parts, even if air storage with very small amount, the lubrication of these parts will be damaged that will cause serious damage.

Before operation, when filling water to circulation pump, the air easily stored in high-pressure cooling water system. When primary operation in the conditions of cold start and low pressure, this air may be taken into the pump. To decrease air gap in pump, should take following measures:

- 1) Before start up pump, must ensure correctly water filling and exhaust according regulation (statement at the back), if operation without water in pump, the bearing will be damaged immediately.
- 2) Motor chamber should maintain water filling in any time, which is extremely important. Therefore, after boiler installation or drainage, isolate the pump and separately take condenser water into each pump according the requirements of chapter 'Primary water filling and drainage of pump', regularly check the reverse pumps and ensure full water in the pumps.

To decrease air gaps in boiler, should take following measures:

- a) Slowly fill water into the boiler, best to fill water from the bottom position of boiler unit.

- b) Confirm economizer recycle valves, economizer exhaust valves and all exhaust valves in drum (including valves 'cleaning and leakage' among all isolating boards and in the area of drum layers) are open. Close 'cleaning and leakage' before start up the first pump.
- c) Before start up pumps, confirm the high level in drum, the level best to reach the top of glass water gauge, and maintain an appropriate level after pump started up.

3 Air and Flue Gas System

3.1 ID System

Specification and performance of fan

3.1.1 Fan Main Parameter

Wheel diameter	3.75
Rotate speed	590
Rotor weight:	5000
Fan weight	52000
GD2 (kg.m ²)	20400
Cooling fan model	G9-19No5A

3.1.2 Performance Parameter of Fan

Item	Unit	TB	B-MCR (worst coal)	B-MCR(design coal)	TMCR (design)
Fan Flow	m ³ /h	2196096	1738576	1711944	1572829
Pressure drop	Pa	5136	3824	3664	3544
Inlet temp.	°C	140.5	130.5	130.5	128.9
Fan Shaft power	kW	3890	2268	2121	1881
Fan efficiency	%	81	83	85	85

Motor power kW 4300

Fan rotor speed r/min 590

3) Parameter of motor

Motor type YBPKK1120-10

Rated power (kW)	4300
Rated voltage (kV)	11
Rated speed (r/min)	740

3.2 FD System

Technical Data

Internal diameter of the fan	2660 mm
Diameter of the impeller hub	1412 mm
Stage number	1
Number of blades per stage	14
Blade material	HF-1
Connection blade/blade shaft	screwed
Diameter hydraulic cylinder	Ø336/H100MET
Hydraulic stroke	40°
Impeller adjustment range	-30°~+20°
Gap between internal fan diameter and outer fan diameter (blades in closed position)	2.66~5.32mm

Design Data List of Forced Draft Fan

(Metric system)

Fan Type: FAF26.6-14-1

Operating Point	Unit	T.B	B-MCR (worst coal)	B-MCR (design coal)	TMCR
Volume Flow	m ³ /h	907398	718357	735158	665782
Barometric Pressure	Pa	93760			
Inlet Temperature	°C	50.00	50.00	45.50	45.50
Loss of Plant	Pa	4323	3235	3252	3174
Total Pressure	Pa	4458	3319	3340	3247
Fan Efficiency	%	88.58	84.80	85.19	82.16
Fan Shaft Power	kW	1247	771	791	722

Fan Speed	r/min	990
Motor Output	kW	1400
Inertia Moment (J = 0.25GD ²)		535

3.3 Air Heater

Air heater is a kind of heat exchanger utilizing flue-gas heat of boiler back-end to heat air needed in combustion. Owing to work at the area of lowest flue gas temperature, it recovery flue gas heat, and reduced outlet gas temperature, therefore boiler efficient improved. Meanwhile, temperature increased of combustion air is favor of fuel burning and combustion as well as reduced the loss of incomplete combustion.

Air heater followed heat-transfer way to be divided into: two kinds of heat transfer and heat storage (regeneration). The former is to transfer heat to air continuously by flue gas through heat transfer surface, the gas and air have their own channels. The latter is gas and air alternately flowed through heating surface, the heat is transferred to metal of heating surface by flue gas and is stored by metal, then the air transfers heat to air through heating surface; like this to cycle hearting continuously. In power plant, conventional heat transfer air-preheater is pipe air-preheater, heat storage air-preheater is rotary air-preheater. With the increase of steam parameter and unit capacity of power plant boiler, due to heating surface increased, the volume and height of pipe air preheater will be increased, which will affect boiler arrangement. Therefore, current large units adopt rotary air-perheater with compact structure and light weight.

Ratory air-preheater consists of cylindrical rotor and fixed cylindrical shell, flue air duct and gearing. The heating surface is installed on rotating rotor, which is divided into several sector grids; each grid is full of heat storage boards made of wavy metal sheets. Top and bottom of cylindrical shell are divided into three parts of flue gas circulation area, air circulation area and sealing area (transition zone) at corresponding upper and lower (see figure 5-21). Flue gas flow area connected with flue duct, air flow area connected with air duct, sealing area neither flowed with flue gas nor flowed with air, so the gas and air are not mixed. The rotor with heating surface is rotated through gearing. So heating surface constantly alternates flow area with gas and air flowing, thereby to finish heating exchange. The rotor rotated a cycle meant to finish a heating exchange process. Besides, due to large gas flow, the flow area of gas accounted for about 50% of the total cross-section of rotor, air flow area accounted for about 30% - 40%, and other parts are sealing area.

In this plant, boiler is equipped with two air preheaters, the model numbers are 32.5-VI (T) – 2333 – SMR.

In the unit, rotary air preheater is set to be type VI, three points storehouse semi - module and built-in block bearing.

Transmission of air preheater adopts centre transmission. Center transmission device includes a main motor and a auxiliary motee with pneumatic motors.

The air-preheater is equipped with leakage air control system. Each sectorial board is equipped with a set of leakage air control system lifting mechanism, the function of leakage air automatic control system is to

automatically track and control the sealing clearance between hot end sectorial board bottom and rotor radial seal of air-preheater during working time.

3.4 Electro-Static Precipitator

The principle of dust collection in an ESP as follows:

When passing through the high voltage electrostatic fields, dust particles will be charged by colliding with positive ions, negative ions and electrons among electrodes or in the ion dispersion movement. The particles with electrons and ions on them will move and accumulate on the electrodes of opposite polarity under the influence of the electric field. By means of rapping, the layer of dust particles on the electrodes will be dislodged into the bottom hoppers.

Practice has shown that the higher the strength of electrostatic field, the more effective as ESP will be and it is preferable to capture dust particle in and ESP operation with negative corona, therefore, our ESPs are designed as the structure of high voltage negative corona electrodes.

Structurally an ESP is divided into two portions, electrical portion and mechanical portion. Its main components and functions are described respectively as follows:

3.4.1 Electrical Portion

The electrical portion comprises high voltage DC power supply including to their control system and low voltage control system.

High voltage DC power usually consists of high voltage transformer rectifier, auto-control cabinet and reactor or high impedance transformer rectifier and auto-control cabinet. This power supply can automatically adjust the voltage applied to the electric field according to the changes of gas conditions therein and can adjust the spark ratio in the field at the optimum level according to feedback signals from current so as to achieve the effects of dust collection in the best way.

This power supply is equipped with perfect interlocking protective system.

It is possible to set extra computer management system and upper level machine in the power supply followed by customers' request.

Low voltage control system and its functions:

- 1) Programmable control of rapping for both collecting and discharge electrodes;
- 2) Control of heating for high voltage insulators and heating temperature;
- 3) Control of indication and alarming for ash level;

- 4) Control of ash removal and transmission;
- 5) Control of safety interlocking for doors, holes and cabinets;
- 6) Functions of electrical heating of hopper;
- 7) Measurement and indication of inlet and outlet flue gas temperature;
- 8) Set up the functions and parameters of low voltage system through Remote Supervisor Unit;
- 9) Indication of comprehensive signals and alarm;

3.4.2 Mechanical Portion

This portion can be structurally divided into internals, casing and auxiliaries.

The internals parts include: Collecting system Discharge system Collecting rapping system, Discharge rapping system. Rapping devices are of great importance to ESPs. By rapping, dust accumulated on both collecting plates and discharge electrodes are dislodged and fallen into hoppers. Both collecting and discharge rapping systems use rotary hammers to carry outside rapping.

The casing parts include: inlet nozzle (inlet funnel) outlet nozzle (outlet funnel) , roofs , casing, hopper ridge beam (bottom beam) and hopper. To ensure good insulating status of insulators, electric heating devices are installed inside the insulator compartment to maintain its dryness,

Hopper ridge beam is used to connect components of casing with hopper. Hopper is a container which used to collect dislodged dust. Anti-sneaking baffles are installed inside the hopper, which prevent flue gas from bypassing the hopper, thereby leads to reduction of collecting efficiency. The hopper must have a correct valley angle to ensure that ash can flow down by itself in the hopper. To avoid condensation occurrence as a result of dust temperature dropping below dew point, heating device is usually installed on the lower part of hopper (in some cases all over the hopper). Alternatives of hopper heating are either electric heating or steam heating. From the flange at the hopper bottom, pneumatic ash conveying system or gate valve and discharge valve can be connected.

3.4.3 Earth

The ESP is operating under high voltage and normally with negative corona which means its casing and collecting system have the same potential to protect high voltage equipment and ensure person safety.

ESP is a high voltage installation, so special attention must be paid to personal safety whenever the insulator compartment and the inlet part of high voltage T/R are in service. Any person must be away from a safe distance.

The inside of any electric field is a dangerous area of high voltage and no one is allowed to enter during the

operation of the ESP. All inspection doors must be interlocked for safety.

ESP is a dangerous installation at high temperature, high negative pressure and dusty, so no part of the human body is allowed to touch any hot part in its operation. When the ESP is shut down for inspection/maintenance, the inspection doors should be opened to cool down via ventilating and people can enter when the internal temperature drop below 40°C.

If any inspection door is left opened during the operation of ESP with negative pressure status, anyone near the door is likely to be sucked in due to high negative pressure as a result of body injuries and even electric shock accidents by high voltage, therefore, the doors must be securely interlocked.

3.5 Flame Detection Cooling Fan

Flame detection cooling fan provides cooling for flame detection probe. In this project, each boiler equipped with two flame detection fans with 100% of capacity, one for working, and the other one for standby.

3.6 Stack

This engineering has one stack for two boilers, the height is 275m.

4 Milling System of Boiler

4.1 Mill Overview

Shanghai heavy machine factory Co., Ltd. imported bowl mill manufacturing technology from America GE Company (now is ALSTOM Power Inc.) in the early eighties of the twentieth century. Grinding surface in mill is similar to deep disc or bowl, so call it as Bowl Mill.

According to characteristics of coal, the milling system will be positive pressure, cold primary air fans, and direct firing system with medium speed. This system has simple process with good adjustment abilities, lower electricity consumption and lower annual expense.

Because Grindability Index (HGI) of the design coal is 42, it's difficulty to be milling.

Boiler combustion system have four corners tangential-firing mode, which is adopted with six layers of burners (four burners each layer), totally 24 burners for one boiler.

The boiler is equipped with six medium speed bowl mills, in which five in operation and one on standby can ensure continuous operation under BMCR condition. The Boiler is equipped with two (2) 100% capacity sealing air fans, in which one shall be running and one shall be standby.

The boiler has total six raw coal feeders, with measurement instrument and variable speed drive motor. It can be adjustable automatically with boiler load.

4.2 Principle and Process of Mill Operation

Mill is used to grind raw coal, which enabled to achieve coal fineness of effective burning in oven. The maximum output of mill depends on following factors:

Mill specification

Raw coal characteristic -- Hardgrove grindability degree and water content

Coal fineness -- % through 200

Raw coal (diameter is equal to or less than 38mm) is fed to rotating grinding bowl from centre feed-coal tube connected in coal feeder. Coal feeding rate is confirmed automatically according to generating capacity of generating unit, coal quality and mill operated number. After dropped into grinding bowl, raw coal outwardly moved along radial direction to lapping cup under the centrifugal force. Due to the radial and circumferential movement, the coal can pass through under grinding roll device turning about axis; therefore, grinding force produced from spring charger is exerted on the coal by rotating grinding roll. Grinding roll device make the coal to form coal bed under grinding roll, and grind to power between grinding link and grinding ring. During the coal grinding, smaller and lighter particles continuously blow up from grinding bowl by gassy conveying medium (hot air or flue gas).

The air has three functions: firstly, the air convoys power coal to furnace through mill; secondly, it provides necessary power to dissociate coal powder in the mill (control outlet coal fineness); thirdly, during the process of coal grinding the air heated dries the coal and makes it easy to be grinded.

Carrier air is provided by primary fan laid on upper part of mill, and primary fan provides positive pressure. Hot air flows in from the grinding bowl bottom, and the air flows through annular space around grinding bowl into outside diameter of rotating grinding bowl. The blades (are called impeller) on grinding bowl make the airflow tend to vertical direction. Smaller and lighter coal particles on outside grinding bowl are carried upward by air flow, but heavy and unbreakable foreign materials fall into the area of side machine. Here, the foreign materials through side machine baseplate are swept out the mill by scraper devices installed on rotating petticoat, and then took into reject removal system. Foreign materials usually consist of rocks among coal layers and mining machinery components. Therefore, it is advantage to decrease foreign materials in mill to the least.

Lighter coal particles flying on grinding bowl undergo a secondary separation process. Due to applied air deflection device fixed on separator, the first separation occurs rightly on the level of grinding bowel. Here, the

heaviest coal particles directly return to grinding bowl for further grinding to smaller particles. The lighter particles are carried to separator top cover by air flow for secondary separation, here curved adjustable vanes cause the air powder mixture to produce whirlair movement, which lead to heavy particles loss momentum and fall down from coal flow. Heavier coal particles divided from separate blades and venture pipe through inner cone returned to grinding area of grinding bowl. The cone divided turbulent area of coal mill from separate particles. Coal particles in the area without turbulent flow returned to grinding bowl by gravity. The air powder mixture through venture concentrated here, after expanding, to uniformly distribute the air powder in each coal powder pipe. And coal powder pipe introduces air powder mixture into furnace for combustion.

4.3 Primary Air System

The function of primary air is applied to transport and dry powder coal as well as provided air needed in early fuel burning.

Atmosphere vertically flows into two axial primary fans through filter gauge and muffler, and after the pressure-boosting by primary fan divided into two parts; one is the atmosphere flows into cold primary air pipe before mill; the other one is the atmosphere through primary air bin of air preheater, after heated, flows into hot primary air pipe before mill, the hot air and cold air are mixing before the mill. Regulating damper and electric damper are equipped at the outlets of cold primary air pipe and hot primary air pipe to control the air amount of cold air and hot air, to ensure requirements of total air amount and outlet temperature reaches 60-70°C for the mill. The qualified coal powder through coal powder pipe is sent to furnace for combustion by primary air.

The flow of primary air fan mainly dues to primary air amount needed in combustion system and leakage amount of air preheater. The flow of seal air fan is provided by primary air, and it will finally go into mill to constitute a part of primary air. Pressure head of primary air mainly dues to resistance of coal powder flow and flow friction of air duct, air preheater, baffle and mill. The pressure head is changed with the change of boiler needs the powder amount, can be changed air flow by adjusting inclination angle of moving blades, to maintain primary air pressure of air duct and adapt the change of different loads.

Design Data List of Primary Air Fan

(Metric system)

Fan Type: PAF20-13.3-2

Item	Unit	T.B	B-MCR (worst coal)	B-MCR (design coal)	TMCR
Volume Flow	m ³ /h	480589	380466	396902	362550
Pressure drop	Pa	14197	10677	10062	10888

Inlet Temperature	°C	50.00	50.00	48	48
Fan Efficiency	%	88.01	88.01	86.78	88.05
Fan Shaft Power	kW	2073	1246	1247	1209

Motor power kW 2450

Fan rotor speed r/min 1490

4.4 Seal Air Fan

Milling system design is positive-pressure operation, to prevent coal powder leakage outside from milling system during operation, environment pollution on site and to maintain safe and stable operation for milling system. Our milling system equipped with seal air system consisted of two high pressure centrifugal fans. Seal air adopted design of centralized air supply, seal air fan is set at zero meter of boiler, and the air source is from cold primary air main pipe. The outlet of seal air fan equips with seal air main in front of mill, separately educing each pipe branch to seal the mill. Seal air is sent to the gap of static part of rotating equipment in milling system, to prevent coal powder flow in mill leak out from the gap, and ensure safe operation of milling system and environmental health around site. Under normal operating condition, one of the seal air fans is applied to operation and the other one is applied to standby.

4.5 Coal Feeder

Each boiler equipped with six pressure metering coal feeder (each mill equipped one set), its coal supply distance is 2.256m, output is 10~80t/h, weighing accuracy reaches $\pm 0.5\%$, and possesses explosion-proof capability (can bear pressure 0.35MPa), to guarantee medial-speed mill positive pressure direct-fired system can be operated normally. Seal air of coal feeder is directly from outlet pressure cold air main pipe of primary air fan.

4.6 Control and Adjustment of Milling System

Mill should be adjusted after put into operation. Usually the adjustment includes the clearance between grinding roll and grinding bowl, pressure of grinding roll spring, coal powder fineness and grinding coal output, etc.

4.6.1 Adjustment of Clearance between Grinding Roll and Grinding Bowl

When the clearance between grinding roll and grinding bowl is too large, the ability of pulverized coal will be reduced, and the output of mill will be decreased. When the clearance between grinding roll and grinding bowl lining board is too small, impact vibration will occur between grinding roll and grinding bowl.

The principle of clearance adjustment is the smaller clearance the better on the premise of not touching.

The adjustment of clearance is completed through grinding rolls positioned bolts (also called as jackscrew).

1) Adjustment of grinding roll spring pressure

Spring pressure is in direct ratio to spring compression value, spring pressure can be adjusted by adjusting pressure and adjusting bolts. Adjustment of spring pressure is relevant to coal quality, which should be confirmed by tests during adjustment.

2) Adjustment of coal powder fineness

Adjustment of coal powder fineness is finished mainly through changing the opening of separator deflection gate blades, the opening of deflection gate blades is from large to small, and coal powder fineness is from coarse to fine.

Adjust coal powder fineness with deflection gate blades, when deflection gate opening reaches the maximum (in radial direction), the coal powder is still too fine, then needed to reduce pressure of grinding roll spring; conversely, when deflection gate opening reaches the minimum, coal powder is still too coarse, then needed to increase pressure of grinding roll spring, to strengthen milling force from grinding roll to coal layers.

3) Adjustment of grinding coal output

Usually when mill output is lower than 50% of rated output, the pulverized coal concentration at pulverized coal burner output will be very low, which is detrimental to ignition stability of pulverized coal. Another mill output is too low, which is not economical for milling system, and unit power consumption will be increased. Conversely, when mill output exceeds rated value too much, it will lead to unstable operation of mill.

The adjustment of mill output is finished according to the changes of unit load, through adjusting coal feeding amount of coal feeder (coal feeder rotating speed). Usually the adjustable data of mill output will be confirmed by adjustment tests.

Planned mill load scope as following:

	Min.	Max.
Limiting load of two mills	35%ECR	42%ECR
Limiting load of three mills	42%ECR	55%ECR
Limiting load of four mills	55%ECR	75%ECR
Limiting load of five mills	75%ECR	100%ECR

Usually five mills can carry full load for operation, the sixth mill is for standby.

The output of direct-fired system will be increased with the increase of boiler load, and decreased with the decrease of boiler load. Therefore, load adjustment cannot be taken individually, milling economy has been affected. Mill output in operation is adjusted by coal feeding amount. When medium-speed grinding powder

system is used to provide automatic control, it is often use automatic control system with coal feeding amount, primary air amount control and mill output temperature control.

4) Control of air-coal ratio

Medium-speed mill direct-fired system, the ratio of mill ventilation quantity (primary air amount) and coal feeding amount is called as air-coal ratio.

Confirming air-coal ratio has obvious effect not only to operating condition of milling system but also to combustion of boiler. Air-coal ratio (design air-coal ratio) under rated output is confirmed according to requirements of boiler combustion primary air ratio, reliability of primary air pipe pneumatic conveying and economy of milling system. Design air-coal ratio value of medium-speed mill with different models is between 1.2 and 2.2; all can guarantee the necessary air ring air speed and dry output. Higher air-coal ratio is suited to the coal with higher burning volatile matter, lower air-coal ratio is suited to the coal with lower burning volatile matter. The air-coal ratio of normal operation under the working condition of meeting different loads recommended by manufacturer (such as pyrites quantity and coal powder fineness) referenced as following:

Load(%)	35	40	50	60	70	80	90	100
Air-Coal Ratio	3.17	2.85	2.4	2.1	1.89	1.72	1.6	1.5

During mill operation, the air-coal ratio is set to the function of milling output. Maintain a certain air-coal ratio under different milling output is important feature of medium-speed mill load adjustment, this will maintain stability of mill operation and coordination with combustion system. The effect of milling economy by change of air-coal ratio as following: under a certain coal feeding amount, with the increase of air-coal ratio, ventilation power consumption will be increasing and grinding coal power consumption will be decrease a little, but usually milling economy will be less. This is because pulverized coal recycled amount in mill mainly dues to grinding ability, but smaller effect on air amount. Therefore, under the premise of pyrites amount allowed, maintaining lower air-coal ratio in operation to improve economical efficiency. Considering from safety angle, the possibility of plugging grinding when coal seam thickening will greaten, thus it is advantage to increase air-coal ratio suitably. The effect from air-coal ratio to pyrites as following: when low load, thin coal seam at grinding table margin, the small air flow can carry coal powder away, and pyrites amount is not large; when high load, it needs higher air ring air speed to reduce pyrites amount. That is pyrites ratio depends on air-coal ratio, when air-coal ratio maintained at stable value, pyrites ratio will change little. Besides, air-coal ratio will affect mill outlet temperature which needs corresponding adjustment.

When large load change, air-coal ratio confirmation should also be considered other factors. For example, when lower load, due to air-coal ratio is constant, primary air speed becomes slower, the possibility of coal

powder deposition and pipe jamming in primary air pipe will be increased, and the safety will be reduced. On the other side, the flow speed of grinding table air ring will reduce which causes pyrites amount increased as well as will make milling cost be increased. For the burning, air-coal ratio will affect the changes of primary air ratio and secondary air ratio, if pulverized coal concentration reduces too much, which will be very disadvantageous to pulverized coal ignition and stable combustion in low load.

In general, direct-fired system is unallowable to adapt load change only by increasing and decreasing coal feeding amount under the condition of primary air amount unchanged, which will make the air-coal ratio is too large in low load, reduce milling economy and make the combustion deteriorating.

4.6.2 Incorrect Phenomena during Mill Operation

- 1) The same as other machines, mill has correct operation ways and incorrect operation ways. The following list is for avoiding incorrect and dangerous operating conditions.
- 2) Over flow of coal is too much, which is a dangerous condition, owing to the coal will block pyrites discharge, which will be large hidden trouble of pyrites deposited in side machine causes mill ignition.
- 3) Mill continuous operation when outlet temperature is lower than specified value, which is a dangerous condition, owing to the coal cannot be fully dried that adsorbed in mill interior and pulverized coal pipe, to block pulverized coal pipe and lead to mill/pulverized coal pipe ignition.
- 4) Mill operation under the condition of outlet temperature is higher than specified value, which is a dangerous condition, owing to high outlet temperature drives volatile matter to escape from the coal, thus adding potential possibility of fuel ignition. If mill outlet temperature increased to higher than specified value 11℃, control system should automatically close hot air damper (see the section of mill ignition). Mill outlet temperature specified value is confirmed by different coal.
- 5) Mill operation under the condition of ventilation quantity is lower than specified value, which is a dangerous condition, owing to transport speed in pulverized coal pipe too low to make the pulverized coal deposited, this condition will lead to pulverized coal pipeline blockage and ignition.
- 6) Mill operation under the condition of ventilation quantity is higher than specified value, which is a worse condition, owing to higher ventilation quantity makes abrasion accelerated in pulverized coal pipeline and mill interior, meanwhile possibly reduce coal powder fineness.
- 7) Mill operation under the condition of closed outlet gate for discharging pyrites, which is a dangerous condition, owing to this will stop sundries discharge. After slide damper closed for a period of time, the sundries discharged normally will be deposited in side machine. Scraper device will produce serious damage.
- 8) Mill improper warm grinding before coal supply, which is a dangerous condition, owing to the coal possibly

adsorbed in mill interior and pulverized coal pipe that will increase potential danger of milling system producing ignition, see the section of primary start-up steps.

- 9) Mill improper cooling before shutdown, which is a dangerous condition, owing to coal temperature possibly exceeds safety limit, increasing possibility of mill or coal pipe ignition. See the sections of correct normal shutdown steps.
- 10) Too small fineness of mill output pulverized coal, which is a poor operating condition, owing to increased pulverized coal fineness will reduce mill outlet, and increase power consumption of mill and motor.
- 11) Too coarse fineness of mill output pulverized coal, which is a poor operating condition, owing to too coarse fineness of pulverized coal will affect the pulverized coal combustion in furnace.

4.6.3 Fire-proof of Milling System

The usual causes of pulverizer fires are:

- 1) Excessive pulverizer temperatures. Do not allow the pulverizer outlet temperature to exceed the specified outlet temperature by more than 20°F (11 °C).
- 2) Foreign material such as paper, rags, straw, wood and excelsior collecting in the inner cone and other points in the pulverizer. These materials do not pulverize readily and therefore should be kept out of the raw fuel supply. When they get into the system, they collect and may catch fire. Each time the pulverizer is opened for any reason, remove all foreign materials from the air inlet, inner cone, bowl, etc.
- 3) Excessive accumulations of pyrites or coal on the mill bottom or in the air inlet to the pulverizer. The valve on the tramp iron discharge spout should be open to allow the free discharge of foreign materials into the pyrites collection system. The valve may be closed momentarily for their removal of pyrites from the collecting hopper. Accumulations of debris in the air inlet should be removed whenever the pulverizer is open for inspection. Scraper and guard assemblies should not be allowed to wear excessively.
- 4) Excessive accumulations of coal in areas above the bowl. This condition is usually brought about by lack of maintenance. Worn liners may allow coal to accumulate in an area faster than the normal air flow will remove it or to reach areas where it cannot be removed. Coal can also be trapped by foreign material bridging a section of the pulverizer through or over which the coal would normally move, i.e. an obstruction on top of a liner cover plate.
- 5) Improper or unusual operation. Accumulations of coal or flammable foreign material are a hazard under normal operating circumstances, but in most cases they do not of themselves cause fires or puffs. Usually some additional improper operating condition must initiate the trouble. For instance, if a pulverizer is operated with low air flow, higher pulverizer inlet temperatures are necessary to maintain the set outlet

temperature. The air flow may be low enough to allow additional settling out of coal from the air stream. These conditions can result in more heat, less coal movement and potential trouble. Another example would be failure to close the hot air gate when there is reason to believe an operating condition may have allowed a fire to start. Such a condition could be a sluggish damper drive mechanism or a sluggish damper control system coupled with a substantial and rapid change in coal moisture. An example of unusual operation would be running coal through a pulverizer from a bunker that is known to be on fire. Of course, extreme care must be taken while doing this. Everything possible must be done to ensure that coal feed is continuous at a moderate to heavy rate.

- 6) Feeder hot air. When the feeders use hot air, it is important to close the feeder hot air valve whenever there is a possibility that the feeder will be stopped for longer than 3 minutes with coal in it

COAL PULVERIZER FIRE FIGHTING PROCEDURE

Pulverizer fires are detected by high pulverizer outlet temperatures [temperatures more than 20°F (11 °C) above the specified outlet (normal operating) temperature]. Pulverizer outlet temperature detection devices should monitor and alarm when the outlet temperature reaches a set point value. This alerts operators to the potential presence of a fire.

- 1) At first indication of a fire, close the hot air shutoff gate and open the cold air damper to 100 % Continue feeding coal at a rate equal to or above the feed rate that existed just prior to the fire. Use care not to overload the pulverizer.

NOTE

Closing the hot air shutoff gate will frequently extinguish the fire, if the pulverizer temperature continues to rise, it will be necessary to cool the pulverizer by admitting water.

- 2) Close the pyrite hopper isolation valve.
- 3) Introduce water through the nozzles provided on the air inlet, mill side and separator top Nozzles are provided on the separator top, mill side and air inlet duct. It is recommended that the nozzles be connected to a permanent piping system and water supply with suitable valving.
- 4) Continue to feed coal and water until the pulverizer outlet temperature has dropped and all signs of fire are gone.

NOTE

Water should be admitted in such quantity and at such location(s) as not to cause hang-up or interruption of the fuel feed or disturb any deposit of combustible material.

- 5) Shut off the water supply.
- 6) Stop the coal feed.

- 7) Run the pulverizer for several minutes to purge the system of accumulated coal and water.
- 8) Stop the pulverizer. Isolate the pulverizer by closing all gates and valves, cold air shutoff valve, seal air valves, coal pipe shutoff valves, etc.
- 9) Use plant procedures; isolate the pulverizer and feeder motors, open breakers and tag.
- 10) The pulverizer should be opened, inspected and its contents (coal) removed. Entry into the pulverizer will be made through the inspection doors in the separator body and through the mill side doors. The following procedure is to be followed when opening these or any other inspection door in the pulverizing system.
 - a) Ensure that the pulverizer has been isolated and the motor breaker has been racked out and tagged.
 - b) Ensure that all door attachment lugs or nuts are present and tightened down. visual only)
 - c) On the door to be opened, remove all but the corner nuts or lugs, Then back off the corner attachment lugs halfway.
 - d) Crack the door free with a crowbar or jar it loose with a hammer. When the seal breaks some coal dust will discharge from around the door.
 - e) Remove the corner lugs or nuts completely.
 - f) Remove or open the door.
- 11) Upon satisfactory inspections of the following areas for evidence of fire or smoldering products of coal or coke, clean up can take place.
 - a) Fuel pipe
 - b) Mill side
 - c) Separator body
 - d) Inner cone and classifier.
- 12) Check the lubricants and replace them if there is evidence of contamination.
- 13) After coal has been removed from the bowl and mill side and the pulverizer has been thoroughly cleaned and repaired as required, it can be restarted. Use normal start-up procedures.

5 Combustion System of Boiler

5.1 Design Coal Characteristics of the Power Plant

The power plant design all use Indonesia coal, the characteristics are high volatile, low calorific value, little ash, moderate moisture, difficult to grinding, low ash fusion point, easy to coke.

Due to Indonesia coal with higher volatile and easy spontaneous combustion, strengthen management during coal

transport, pile on coal storage and belts transport to prevent spontaneous ignition which will cause fire. Note mill explosion prevention in the milling process, the control of primary air temperature and mills feed coal is very important, in the process of stop grinding, pay attention to take fully empty grinding.

Indonesia coal with good flammability, ignition advance, which are easy to cause burner nozzle damaged, pay attention to maintain the control of primary air pressure in operation.

Indonesia coal with lower calorific value and faster burnout, should pay attention to control air capacity in **operation.**

Indonesia coal with lower ash fusion point and easy to coke. In operation pay attention to guard the coke of furnace, burner and screen overheater.

Higher content of Fe_2O_3 in coal is easy to generates dense hard-slag and cause boiler slag discharge impeded.

5.2 Burner

Tilting direct flow burner (waiting confirm burner specific model and manufacturer materials)

PM burner mainly utilize its turning and specific flow speed in pipe to redistribute pulverized coal concentration, the structure shown in figure

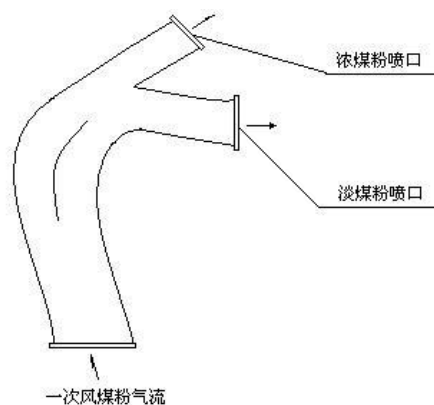


Figure 2 PM thick and thin coal powder separation burner figure

Due to burning coal with high volatilize and low ignition point, therefore, the choice of the burner emphasis on improving the combustion efficiency.

5.3 Fuel Oil System

In current project, boiler ignition oil is light diesel oil; boiler adopts level-2 ignition, i.e. from high-energy igniter to light oil, and then pulverized coal. In burner management system (BMS), boiler automatic ignition, oil burner automatic switching; boiler fuel-supporting oil is heavy oil. According to the oil material provided by owner, kinematic viscosity is 180CST(15°C). To meet the requirement of boiler oil burner feeding oil is viscosity 20E,

Must at heavy oil pump outlet set fuel oil heater to meet combustion requirements.

Four corners of each boiler has $6 \times 4 = 24$ burners, total $4 \times 4 = 16$ oil burners, among these four light oil burners, 12 heavy oil burners. Oil consumption of each light oil burner is 3.35t/h, total outputs of 4 light oil burners are 13.4t/h, the total capacity is 10% of BMCR input heat when oil burners all put into operation;

Oil consumption of each heavy oil burner is 3.6t/h, total outputs of 12 heavy oil burners are 43.2t/h, the total capacity is 30% of BMCR input heat when oil burners all put into operation. Boiler in burning design coal, boiler minimum load of stable combustion without oil is 40% BMCR.

Heavy oil burners use steam atomization, steam pressure of oil burner inlet is 0.86MPa, inlet oil pressure is 1.37MPa (g). Light oil burners use mechanical atomization, oil burner inlet pressure is 3.43MPa (g). fuel oil system pipe connector at oil tank flange in the scope of owner.

5.4 Fire Supervisory and Industrial Television

Drawing information

Put-in-quit and protection of flame cooling fan

5.5 Burner Management System (BMS)

BMS is a set of system with adjustment, monitoring and protection for total boiler, including following parts:

5.5.1 Public Logic Part

- 1) Main fuel tripping (MFT)
- 2) Furnace purge
- 3) Leakage tests of light and heavy oil
- 4) Ignition permissive conditions
- 5) Furnace ignition permissive conditions
- 6) Oil ignition permissive conditions
- 7) Coal ignition permissive conditions
- 8) Light oil tripping
- 9) Heavy oil tripping
- 10) RUNBACK
- 11) Furnace pressure protection
- 12) Flame cooling fan control

- 13) Seal fan control
- 14) Light/heavy oil and import/return oil fast valves control

5.5.2 Oil System Control:

- 1) Oil burners ignition permissive conditions
- 2) Light/heavy oil burner startup/stop sequence control
- 3) Oil burner lost and flame detection monitoring
- 4) Oil burner tripping
- 5) Oil burner automatically put in/quit control

5.5.3 Coal System Control

- 1) Mill startup/stop sequence control
- 2) Mill startup permissive conditions
- 3) Mill emergency shutdown conditions
- 4) Mill lube oil station control
- 5) Coal feeder control

6 Boiler and the another Auxiliary System

6.1 Industrial Cooling Water System of Boiler Auxiliary

Temporarily lack of drawing information

6.2 Boiler Expansion System

In order to take accurate thermal-expansion displacement account, a changeless expansion center under various conditions should be ensured as the zero point of thermal-expansion displacement account. This expansion center is so-called artificial expansion center. As for all kinds of single-furnace boilers, expansion centers are installed on the longitudinal furnace centerline.

The channel iron is welded on membrane water wall, bending plate is welded on it every certain distance and angle is welded on the top of bent plate, this is typical strip structure. With strip, buckstay can bear load of different direction caused by positive or negative pressure, between bent plate and buckstay relative slide is allowed to meet requirement of expansion difference. But relative slide is not allowed between bent plate installed on zero

expansion line and buckstay. In order to pass the air load, seismic load and guide load to boiler structure, guide device should be installed in zero expansion point, and the place where has guide device is installed with anti-shearing support other places are installed with fixed strip.

Pylons around boiler roof enclosure frame are hanged to the beam by hanger plate. Zero expansion point of the height is on the elevation of the top of insulation layer which on the boiler roof enclosure. When startup the temperature of penthouse is 260°C (no medium flow) and 370°C (with medium flow). When operation the temperature of penthouse is 425°C, headers of penthouse and tubes between lower part of headers and roof tubes all have different temperatures separately. The tube adopt sealing weld structure where passing the roof, header toward roof tube has a upward expansion quantum, roof tube expand downward, so under every condition the two different expansion quanta should be considered to account the actual displacement direction and quantum. Absorb the displacement quantum by spring hanger or constant hanger of furnace roof, the components under roof tube expand downward in their relative temperature.

Take boiler center line as zero expansion point on the wide direction, and expand to two sides as per relative temperature. But as to the header placed on furnace roof and cut by boiler center line, should superpose the expansion quantum which take 1/4 of furnace width as zero point and calculated as per header temperature to the expansion quantum which take boiler center as zero point and calculated as per saturated temperature at the 1/4 part.

In air and gas duct, the duct which has max temperature and max displacement is the secondary hot air duct and the AH connect duct. One end of secondary hot air duct is connected with furnace air box and moving downward with the furnace and expanding to back furnace at the same time, the other end is connected with more fixed rotary air preheater. The connect duct is like this, so secondary hot air duct and the connect duct all installed with two lines of expansion joints, and decide joints' number of double bellows expansion joints with full wave and the distance between the two lines of expansion joints according to their displacement. To hang them constant hanger which can support more displacement quantum should be used. As to other cold and hot air duct all installed with expansion joint to meet the expansion quantum under cold state and operation.

The two rotary air preheaters of the boiler all have 8 supports each which are placed on horizontal beam with 13700 elevations, between each supports and supporting beam placed one expansion device which friction coefficient is 0.1 to reduce friction force of AH expansion along horizontal direction. So on horizontal direction free expansion is carried through from rotor center of AH to different sides, on vertical direction upward&downward free expansion is carried through as per support side. The connecting part of air and gas duct and expansion device should installed with expansion joint so that the expansion force of air and gas duct would not be passed to the rotary air preheaters.

The attached thermal expansion system drawing (see drawing 01—09~01—11) indicates the expansion condition of different parts. The direction of arrowhead is the expansion direction, and the number beside arrowhead indicates the expansion quantum on this direction (unit: mm).

Realize boiler proper and some relative independent parts such as expansion character of preheater etc and take accurate displacement account of thermal expansion. It is very important in boiler design because it provides basis to given clearance、 seal design、 choice of expansion compensation elements like expansion joint、 selection of spring and constant hanger, structure treatment to components which have relative displacement under cold\hot state and stress analysis to the piping system of pressure parts. Personnel of boiler design、 assemble、 start up commissioning and operation should realize expansion direction and expansion quantum of every parts under hot state, and consider this during designing and assembling. A through inspection should be carried out before the first cold start to ensure the correct assemble of guide device. According to the design sufficient space should be reserved around the components which may have free expansion under hot state. When boiler startup the expansion should be supervised to prevent having accident which caused by components bearing needless restriction under expanding.

VII. Instruction for boiler structure

The boiler adopts outdoor mode, and the structure is truss system, elements are connected by high-intensity bolt in pinned connection type, the support width of structure is 37.6m, longitudinal depth is 49.0m, elevation of main plate girder is 86.7m. Along the boiler height direction, structure can be divided into five levels, the scope of every level is 0~8.65, 8.65~17.0, 17.0~38.5, 38.5~63, 63~86.7, . Eleven levels of horizontal supports are placed in total and column has nine sections, the connecting place is 1150mm higher than every horizontal support. 39 columns are placed at zero-meter point, anti shearing plan of the structure is arranged at axes of H, L, N, B0, and B37.6. The stabilization of boiler structure is decided by rigidity plane and resist cut stand support.

There are A、 B、 C、 D、 E and F eight main girders, max. dimension (length×height×width) is 24.6×4.00×1.5m, net weight is 108t, A、 B、 C main girders are placed on supports on column top directly, the two ends of E and F main girders and columns or other beams are connected by high-strength bolts. Pressure parts of boiler proper are hanged to the hanging beam by hanger, then connect hanging beam to the high place of supporting beam, elevation is 80.84m, see drawing 01—14 and 01—15.

Elements of the integral boiler structure are 5500; Twist-shear type high-strength bolt connection are about 100,000 sets. The connection joints of column, beam, vertical supporter and horizontal supporter are showed in drawing 01—16.

The type of elements section adopt welding combination cross section of “I” shape, main forced elements adopts low alloy steel Q345-B, the surfaces of all elements adopt technology treatment, the friction coefficient of

connecting surface of high-strength bolt is no smaller than 0.4, twist-shear type high-strength bolt connection are formed by a bolt (20MnTiB), a nut (15MnVB or no. 35 steel) and a gasket (no.45 steel).

Stairs of platform are concentrated placed at the two sides before boiler and corresponded to the elevator; the plates of platform adopt bolt fixed construction for galvanized grid.

6.3 Supervisory System of Transpiration for Boiler Pipe

The boiler four-pipe leak is the water-cooled walls, economizer, superheater, reheater leaking accident. Boiler tube leak is common malfunction in thermal power plant, average happen 1 or 2 times each year. Its characteristic is developing very slowly in the early days, and the leak is non-destructive, the duration is usually several days or several weeks, then the leak will develop into destructive leak, the leak in one point may destroy surrounding pipes, if not control, all pipes in the furnace will be destroyed.

6.3.1 Main Function

- 1) Micro-leak early diagnoses and alarm.
- 2) Real-time bar chart show peak value and state of each channel background noise.
- 3) Each channel background noise history data auto-record and analyze.
- 4) Automatic signal FFT analysis function.
- 5) Non-leak signal automatic elimination and weakening.
- 6) Intelligent automatic alarm function
- 7) Alarm record and automatic show the position of the leak area chart.
- 8) System failure automatic diagnosis function.
- 9) System hardware self-checking function.
- 10) The waveguide electrical eliminate soot function.
- 11) Historic record printing function.
- 12) Real-time monitor each detecting point furnace noise, volume adjustable.
- 13) Merge DAS, DCS and MIS system's network function.
- 14) Can accurately discriminate boiler pressure pipe leak noise and the boiler background noise.
- 15) Can judge the position of the boiler pressure pipe leak area accurately.
- 16) Auxiliary monitor soot blowing operating condition

System operation shown in instructions provided by the manufacturer

7 Boiler Start

7.1 Boiler Cold Start

The definition of the boiler cold start: Cylinder metal temperature drops to about within 40% of full load value at the side point.

7.1.1 Check Operation Regulation before Boiler Startup

- 1) Boiler fire-extinguishing protection and other interlock protection are normal after tests.
- 2) Major instruments are complete with reliable and correct indication.
- 3) Check control system is normal and reliable
- 4) Check drum level indicator, normal breakers of steam valve and water valve, level indicator in good use.
- 5) Everywhere expansion indicators are installed correctly and firmly, expansion clearance is enough, expansion displacement unimpeded.
- 6) Check pipe hangers are complete and firm, integral lock of spring hanger should be removed.
- 7) Check everywhere insulation is good, rotating mechanical protection cover is good.
- 8) Check boiler inner without sundries.
- 9) Check boiler manhole door, flame monitoring hole, observation hole, inspection door and explosion door, etc. are close.
- 10) Check drainage gates are close on left and right sides of boiler bottom.
- 11) All switches of boiler flue gas-air baffles in the right direction with same indication inside and outside, flexible and reliable operation.
- 12) Oil system check:
 - a) Oil system with normal oil supply, oil burner and ignition gun are reliable with good performance.
 - b) Each valve CB in system is flexible and good in use.
 - c) Oil speed break-valve action is flexible with tight close and position status indicated correctly.
 - d) Manual valve is closed tightly for oil burner return oil; oil main pipe drainage valve is close.
 - e) Plant compressed air system input, oil burner air source input.
 - f) Oil burner purge air electric door power transmission, CB is flexible and easy to use.
- 13) On the control plate, signaling system is normal, the instructions meters, recording instruments put into well.
- 14) Fan and feed water pump, etc. auxiliary machinery checked finished before startup.
- 15) Boiler water dosing system is complete, and water-steam sampling devices are complete.

- 16) Safety valve full flow exhaust pipe, the installation is firm, spring intact, without sundries to disturb the action.
- 17) The valve name tags and CB direction tags correct, all the valve position of steam and water system according to start-up operating card to finish operation.

7.1.2 Main Steps of Startup:

- 1) Start a circulating cooling water pump, a condensate pump, to water injection the deaerator. Check closed cooling system is normal.
- 2) Check the ash vibration dozens and ash hopper heating substation is normal.
- 3) Boiler feed water, the process should be carried out slowly, control appropriate flow, injection time is no less than 2 hours, closely monitoring temperature difference between drum upper wall and nether wall, water temperature is not lower than 40°C, then stop furnace pump, to increase temperature by changing the water.
- 4) Check boiler bottom and establish water seal.
- 5) Start up the boiler water circulating pump. Open the drum air valve, boiler system hydrophobic valve and recold hydrophobic valve; the burner angle is set to 0°, put into the boiler slag conveyor and boiler blowdown expander cooling water.
- 6) Check lubrication, top axis, jigger, sealing oil and stator cooling water system is normal, generator hydrogen pressure, purity is normal, turbine regulating monitoring and protection system is normal, to make control liquid temperature is greater than 35 ° C.
- 7) Start up air preheater, induced draft fan and forced draft fan system, furnace flame monitoring system, put into fan heater.
- 8) Input high pressure bypass, to open reheater to an empty valve, open superheater hydrophobic, check the turbine proper drainage is open.
- 9) Boiler purge, regulating fan and wind-box damper, make purging air volume is at least 30% of all air volume, furnace negative pressure is about 117.6Pa (water column reference value 12mm)
- 10) Fuel oil leakage test
- 11) Light two light oil burners at the bottom.
- 12) By the boiler boost curve, to control main steam temperature rise rate to be 2 ~ 3°C, drum water temperature rises 110°C/h.
- 13) Depending on the steam, input heavy oil steam heating system
- 14) Drum pressure reaches 0.2Mpa, check the boiler side air valve shut off automatically.
- 15) During warming boiler, open economizer recycling valve, taking boiler purge as required, to maintain drum

- water level in normal level. Before drum steam pressure reaches 0.689MPa, start up the third circulating pump, in order to reduce temperature gradient bore by cycle pump shell. When boiler with full load, should put into three pumps for operation, in order to provide greater flexibility of load adjustment, and to avoid possibilities of reducing load caused by one circulating pump accident when two circulating pump operation.
- 16) When main steam pressure rise to 0.3 MPa, check the following hydrophobic motorized valve should be shut down automatically and close its former isolation manual valve: Roof superheater outlet drainage valve, cladding front wall drainage valve, cladding side wall drainage valve, cladding back wall drainage valve, low-temperature superheater inlet drainage valve, screen overheater inlet drainage valve, screen overheater outlet drainage valve, high-temperature superheater inlet drainage valve, high-temperature superheater outlet drainage valve.
 - 17) When drum temperature reached 190°C, the boiler entered hot cleaning stage. Contact chemical personnel for taking sampling tests and in accordance with the guidance of chemical personnel to take boiler hot cleaning. Before the water quality does not met the requirements, it is forbidden to step up pressure with load.
 - 18) When auxiliary steam temperature reaches 220°C, input turbine shaft sealing system; when the shaft seal pressure and temperature are proper, start up condenser vacuum system.
 - 19) When condenser steam pressure is proper, switch deaerator and exhaust steam to the condenser.
 - 20) According to the heating curves to increase and cast oil burners. Control the furnace outlet gas temperature is lower than 538°C; if without warming cylinder requirement, it is available to open high pressure bypass highly and delay temperature increase.
 - 21) Drum pressure reaches a certain value, close drainage of superheater.
 - 22) Reheat steam pressure reaches a certain value, condenser steam pressure is normal, put into low bypass, manually open low bypass, maintain the opening to more than 15%, gradually turn small reheater drainage.
 - 23) Put into deaerator and reheat it, manually control the opening of regulating valve.
 - 24) When the main steam flow reaches a certain value, input high pressure bypass and temperature control automatically (temperature setting value is between 250°C and 330°C), and ensure steam temperature with 30°C of superheat degree after input high pressure bypass .
 - 25) Vacuum arrives at 150mbar, start up control liquid pump.
 - 26) Input oil burner on high level according to the situation of steam temperature and air pressure.
 - 27) In process of temperature-increasing and pressure-increasing, main steam pressure is controlled to 5Mpa below by the cooperation with turbine high pressure bypass; maintain reheater pressure is no more than 0.824 MPa.
 - 28) Vacuum reaches normal value, and then set turbine.

- 29) Check turbine return warm is normal.
- 30) Take safe passage test, stop direct flow oil pump after the test.
- 31) If the steam temperature is appropriate, to roll the turbine and accelerate return-warm. Check the conditions of unit vibration and cylinder expansion in rolling process.
- 32) Warm # 6, # 5 low pressure heater, when discover steam temperature with trend of fast lifting, manually open bypass, pay attention to adjust the opening of low pressure bypass and change of drum level. The temperature does not be rose as much as possible.
- 33) Return warm ends, rolling the turbine to 3,000 revolutions, inspect unit vibration and cylinder expansion is normal in the rolling process.
- 34) Singly control stop exchange lubrication oil pump, pay attention to the hydraulic change.
- 35) Notice central dispatch and switching station, forthcoming parallel in. Close the main transformer neutral-point earth breaker, main transformer outlet and bus side isolating switch. Check excitation regulating mode, close the excitation switch, and check the paralleling program and start up it after met the conditions. After paralleling, open or maintain main transformer neutral-point earth breaker according to the requirements.
- 36) After paralleling, observing turbine with initial load, adjust the reactive power. Set target load, rise load slope to 2MW/min, and load rose.
- 37) Adjust excitation regulating mode, according to curve to carry reactive load, add boiler fuel, control steam pressure, flow, input desuperheating water and adjust water temperature must be slowly.
- 38) Managed to put high pressure bypass into automation
- 39) Put into low pressure heaters #5 and #6, start up drainage pump.
- 40) Warm high pressure heaters #1, #2, #3 and gradually put into #3.
- 41) Open largely deaerator recold heat, note the recold pressure change. Close reheat pipe drainage.
- 42) Start up two primary fans.
 - a) According to combustion condition to put into oil burner, start up the first mill.
 - b) Continually put into mill to create conditions for switching high pressure cylinder.
- 43) In turbine warm-up period, when the air preheater outlet second air temperature is more than 100℃, again take warm grinding to mill C.
- 44) After put in the mill, depending on the oil burner number (no more than 4 oil burners) to put into ESP, lift load after high cylinder switching, and note turbine stress limit.
- 45) Continue to put into mill for operation.
- 46) Switch plant power to high voltage transformer. Close main steam pipe drainage.
- 47) Load rises to 72MW, check units drainage finished, gradually put into high pressure heaterts #1 and #2.

- 48) Stop air heater
- 49) Close high pressure bypass completely, put into units and coordination control, put into turbine load adjustment.
- 50) When unit load reaches 180MW, parallel in a turbo-feed pump for operation, and inform chemist to check water quality.
- 51) When conditions met, gradually put into pump #4.
- 52) Continually put into mill, gradually stop oil burners and oil pumps completely.
- 53) When the unit load is more than 350MW or economizer inlet flow is more than 1000T/H, parallel in the turbo-feed pump, stop motor-driven feed pump and put into interlock for standby (spoon tube position at 20%), follow the screen of "boiler start-stop" to put the rotating speed of two turbo-feed pumps into automation.
- 54) After the unit loads reaches 540MW, main steam pressure achieves rated value, take complete inspection to boiler body and steam water systems.
- 55) Rise load to target load, set temperature to target value.

7.2 Boiler Warm Start

Definition before boiler warm startup: shutdown for 10 to 72 hours, cylinder metal temperature is about 40% to 80% of full load at the test point.

7.2.1 Main Steps of Startup:

- 1) Check at least one circulating cooling water pump is operating, close cooling water system, air preheater, flame scanning cooling fan, check boiler bottom water seal, top shaft lubrication jigger, boiler pump operates normally. Generator sealing oil, oil hydrogen pressure poor, stator cooling water system, fans, and mill lube system are normal. Turbine adjustment monitor and protect system are normal, ESP hopper heated, vibration put into, control liquid temperature is higher than 35° C. Check turbine proper drainage valve opened. Water level of condenser and deaerator is normal. Electric system, public system and fuel system took start-up preparation well.
- 2) If there is no condensate pump operation, start up a condensate pump.
- 3) Start up a boiler feed pump.
- 4) If there is auxiliary steam provided from another unit, which will be used to heat feed water tank, and put into shaft gland, when temperature and pressure reach, to create vacuum.
- 5) Set inclination of burner to be 0° , put into slag-off machine, expansion tank cooling water.

- 6) Re-cold drainage valve put into subcontrol, set main steam and reheat steam temperature value according to the scope provided by system.
- 7) Start up air preheater, induced draft fan, forced draft fan system, furnace flame monitoring system, put into fan heater.
- 8) Group control is put into high pressure bypass, open reheater to air valve, manually control high pressure bypass opening to be 10%.
- 9) Boiler purge, fuel oil leakage test.
- 10) If there is no auxiliary steam, ignite two oil burners at level C at latest 2 hours before parallel. This moment boiler pressure is about 50bar.
- 11) Start up boiler overheater drainage according to boiler pressure. Confirm re-cold drainage subunit control put into.
- 12) Boiler firing-up according to start up curve, control steam temperature rise rate to be 2-3° C/minute. If no auxiliary steam, control high pressure bypass, shaft seal drainage, fan heater uses steam, deaerator uses steam to obtain vacuum condition of cast seal pumping.
- 13) According to the condition of condenser pressure, switch exhaust of deaerator to condenser.
- 14) Difference between main steam temperature and temperature in front of valve is 70°C, partly open main steam pipe drainage and reheat drainage.
- 15) Close boiler overheater drainage.
- 16) Reheat pressure reaches 0.824MPa, condensate pressure reaches the requirement, open low pressure bypass by pressure setting value. Maintain a certain opening above. Turn down reheater drainage.
- 17) Confirm reheater air valve is close.
- 18) Slightly open re-cold deaerator, manually control the opening of regulating valve.
- 19) Vacuum should reach requirement, start up turbine control liquid pump.
- 20) Difference between steam temperature and valve base is 50-70°C. Vacuum reaches 120mbar and turbine trip, secure channel test, stop direct flow oil pump.
- 21) Rolling the turbine to 3000r, note the vibration.
- 22) Put into low pressure heaters #5 and #6, start up drainage pump.
- 23) Start up two primary fans, and put into mill C.
- 24) When turbine rotating speed reaches 3000rpm, stop AC oil pump, note the change of oil pressure.
- 25) Inform middle dispatcher and switch station, forthcoming parallel in. Close main transformer outlet isolating CB, check a CB is close at main busbar side. Close main transformer neutral point earth CB, check excitation adjusted at 'N-SEL', close excitation CB, check grid program, start it after meeting conditions. If paralleling

- failed, then grid program quit, meet conditions through change turbine speed and excitation current direction, then restart up grid program.
- 26) After paralleling in, observe the initial load on turbine belt, set target load 80MW, slope rate 6MW/min, rise reactive power to 5Mvar, switch excitation adjustment mode to 'Q', open or maintain main transformer neutral point earth CB according to the requirement. Feed boiler fuel, control steam pressure and flow to create conditions for pulverized fuel feeder and desuperheating water.
 - 27) Warm high pressure reheaters #1, #2 and #3, gradually put into high pressure heater #3.
 - 28) Open deaerators cold reheat; note the change of recold pressure. Close reheat pipe drainage.
 - 29) Slowly adjust desuperheating water to control steam temperature. Try to return high pressure to automatic.
 - 30) Additional put into mill to create condition for high pressure cylinder switching, keep close watch on control primary air temperature and mill explosion.
 - 31) Rise load after high pressure cylinder, close main steam pipe drainage, note the stress, follow condition to start up mill.
 - 32) Switch plant power to high voltage plant transformer.
 - 33) Check unit drainage closed completely (72MW), pipe drainage closed completely.
 - 34) Gradually put into high pressure heaters #1 and #2.
 - 35) After close high pressure bypass completely, put into boiler and coordinating control.
 - 36) Put into turbine load adjustment.
 - 37) When condition met (110MW), gradually put into fourth pump, switch heating steam source of deaerator to the fourth pump.
 - 38) Continuously put into mills and stop oil burners.
 - 39) When four feed oil burners remained, put into electric precipitation.
 - 40) Stop fan heater
 - 41) Gradually stop oil burners and oil pumps
 - 42) If target load is more than 260MW, start up the second open cooling pump.
 - 43) When unit load more than 350MW or economizer inlet flow more than 1000T/H, parallel in the second steam feed pump, stop electric feed pump and put interlock into standby, automatically put into two steam feed pumps.
 - 44) Rise load to target load, set steam temperature and reheat temperature to rated value.

7.3 Boiler Hot Start

Definition of boiler hot start: Shutdown time is within 10 hours, turbine cylinder temperature decline to value which is equal to the value at 80% rated load.

Inspections are completed before startup.

7.3.1 Main Steps of Startup:

- 1) If there is no operating circulating water pump, then start up one set of circulating water pump, and check if the closed cooling water system is normal, and then start up a set of condensate pump to fill water into deaerator.
- 2) Check the ESP vibrator and operation of heater of ash hopper.
- 3) Use auxiliary steam to heat the feed water tank, slowly increase the auxiliary temperature 230°C.
- 4) If the steam drum pressure is lower than 2 bar, open the steam drum vent; open drain valve of superheater, drain valve of main steam and reheated steam pipes; put drain valve of cold-reheated steam pipe into subcontroller. Set the burner oblique angle to 0°, and put into slag extractor, and cooling water of continuous blowdown flash tank.
- 5) Check and ensure the lube oil, jacking oil, barring gear, sealing oil, control oil, control liquid, and stator cooling water system operate normally. Check and ensure the generator hydrogen pressure is normal and with normal purity degree, in order to make the control liquid temperature is higher than 35°C. The turbine control and monitor and protection system are normal. Electric and common systems have got ready for startup.
- 6) Start up air fan, coal mill, and lube oil system.
- 7) If the air preheater is shut down, start up air preheater, start up FTA, FCA, FTB, FCB, FAR systems, and put into air heater before air preheater.
- 8) Check if the FAR air fan operates normally, and then put into furnace gas temperature detector and flame monitoring TV.
- 9) Put into HP bypass, open reheater vent, and check and open the drain valve of turbine proper.
- 10) Start up a set of feed water pump, adjust steam drum water level, and check and ensure the two sets of boiler operate normally.
- 11) Carry out boiler purging, fuel oil leakage test.
- 12) The two oil burners at layer A shall be lighted up before 2.5 hours ahead of synchronization.
- 13) As per boiler booster curve (CXY02), control main steam temperature rise rate 2~3°C.
- 14) Drum pressure reaches 2 bar, and close the steam vent.

- 15) When the auxiliary steam temperature reaches 220°C, put into gland sealing system. When gland sealing pressure and temperature is available, gland sealing system shall be started up.
- 16) Consider the condenser steam pressure condition; transfer the exhaust of deaerator to condenser.
- 17) When steam pressure increases, adjust HP bypass to make main steam flow increase.
- 18) When the steam pressure reaches 5 bar, the two oil burners at layer A shall be lighted up lighted. Control the furnace outlet gas temperature to be <538°C; if there is no require for cylinder warm-up, the HP temperature rise can be delayed.
- 19) When drum pressure reaches 10 bar, close the drain valve of superheater.
- 20) When reheat pressure reaches 5 bar and condenser pressure is lower than 235mbar, then put into bypass manually, and maintain the 15% opening.
- 21) Close the reheater vent. Put into deaerator reheater cold section, and control it opening manually.
- 22) When the main steam flow is higher than 155t/h, put into bypass temperature automatically control (temperature setting value 250°C ~330°C), and ensure the superheat degree of the steam temperature at the back of HP bypass is 30°C.
- 23) After vacuum extraction of condenser, get ready for startup of control hydraulic pump according to the progress.
- 24) Considering the steam temperature, and steam pressure, put into oil burner at the upper layer. Maintain reheater pressure within 15bar.
- 25) According to steam conditions, put into heavy oil steam heater.
- 26) Extract vacuum of condenser, ensure the main steam temperature and valve seat temperature difference complies with the turbine start rotation conditions, and then set the turbine.
- 27) Carry out access way test, after the test, stop the DC oil pump.
- 28) If the steam temperature is available, and the turbine rotation speed reaches 1000rpm, then check the unit vibration during starting turbine rotation period.
- 29) When start the turbine rotation and the rotation speed reaches 3000rpm, then check the unit vibration during turbine rotation.
- 30) Control AC lube oil pump individually, and pay attention to the oil pressure change.
- 31) Coordinate with the central control, and switch yard control to implement synchronization soon. Close the grounding isolator at neutral point, the main transformer outlet CB and bus bar isolator. Check the excitation adjusting method, close the excitation switch, check the synchronization procedure and then carry out synchronization after the conditions are satisfied. After synchronization, close or open the grounding isolator at main transformer neutral point if necessary.

- 32) After synchronization, observe the initial load on turbine, set the target load with gradient of 4.5%, and then increase the load. Adjust the reactive power to 0MVar.
- 33) Switch the excitation regulating mode, increase load as per the curve, feed fuel to boiler, control steam pressure and flow, put desuperheat water, and then adjust the desuperheat water slowly.
- 34) Put into LP heater 5, 6 and start up drain water pump.
- 35) Warm up the HP heater 1, 2, 3, and then put into heater 3.
- 36) Open the deaerator widely, pay attention to cold reheater pressure change, and close the drain valve of hot reheat pipe.
- 37) Start up two sets of primary air fan.
- 38) According to burning condition put into heavy oil burner, start up a set of coal mill to create conditions for switching to HP cylinder.
- 39) After putting into coal mill, put into ESP according to quantity of oil burner (≤ 4). After switching to HP cylinder then increase the load, pay attention to the stress and reactive power, then continue to start up coal mill.
- 40) Switch the power supply from auxiliary power to unit auxiliary transformer. Close the drain valve of main steam pipe.
- 41) When the unit load is less than 20%, check and close all the drain valve of the unit, and put into heater 7 gradually.
- 42) When the condition (load is $>30\%$) is satisfied, put into steam extraction stage 4 gradually.
- 43) Close HP bypass completely, put into unit coordination control, and put into turbine load regulation.
- 44) If the target load is 260 MW, start up the second opened circulating cooling water pump.
- 45) Shut down air heater.
- 46) Shut down the oil burners and oil pumps gradually.
- 47) When the unit load is higher than 350MW or the flow at economizer inlet is higher than 1000T/H, connect the second pneumatic feed water pump, shut down the motor-operated feed water pump and switch to interlocked standby, and then put into automation of two sets pneumatic feed water pump.
- 48) Increase the load to the target value, and set the main steam temperature and reheat steam temperature to the rated value.

7.4 Boiler Extreme Hot Startup

Definition of boiler extreme hot startup: Shutdown time of the unit is less than 1 hour, and the metal temperature of

the cylinder is close to the value at rated load.

7.4.1 Main Steps of Startup:

- 1) After boiler tripping, check all the oil burners. Trip the coal feeder, coal power system, and primary air fan, and open the recirculating valve of economizer. Close the desuperheat water isolating valve, close HP bypass after quick open for 15 seconds. Pay attention to the water level, and maintain the operation of boiler water pumps.
- 2) If the boiler is implementing soot blowing, shut down the soot blowing.
- 3) Check the turbine tripping and the reheat steam stop valve of the main steam, and close the regulating valve. Lock the check valve of steam extraction and the check valve of HP cylinder exhaust. Open the vacuum drain valve, isolate the HP cylinder. Open the drain valve of turbine proper, LP cylinder spray water, drain valve of steam extraction pipe. Close the motor-operated valve of steam extraction stage 3,4,6,7.
- 4) Check AC lube oil pump and jacking oil pump, start the barring gear motor.
- 5) Check the main CB and excitation CB are opened, and switch the power supply of the unit to startup & standby transformer.
- 6) Quit ESP.
- 7) Check if LP bypass is opened and then open desuperheat water of bypass.
- 8) Put into HP bypass through central control, and manually open a small opening to maintain the gland sealing and vacuum.
- 9) Find out the tripping causes, and ensure they will not influence the re-startup.
- 10) Check the air preheater, FD fan, ID fan, and furnace flame scanner system. Ensure the slag extractor system is normal, the burner gradient is 0 degree, and cooling water of continue blowdown flash tank is put into, and put into air heater if necessary.
- 11) Open reheater vent, manually control the HP bypass opening to 10%.
- 12) Carry out boiler purging and fuel oil leakage test.
- 13) Light up the two upper oil burners
- 14) Strengthen the boiler combustion; control the gas temperature rise rate to 2-3°C/minute.
- 15) Determine whether to open the superheater drainage by boiler pressure and temperature. Check and ensure the drainage of cold reheat steam is put into. Open the drain valves of main stem pipe and hot reheat pipe with small opening.
- 16) Close the drain valve of boiler superheater.
- 17) Put into LP bypass; maintain a certain opening to ensure there is a certain steam flow during startup period.

- 18) Close the vent of reheater, check if the cold reheat to deaerator is put into, and then manually open the opening of regulating valve.
- 19) The difference between steam temperature and valve seat temperature is 50-70°C. Vacuum degree reaches 120mbar, latch the turbine, carry out safety access way test, and shut down the DC oil pump.
- 20) When start the turbine rotation and the rotation speed reaches 3000 rpm, then pay attention to the vibration.
- 21) Put into LP heater 5, 6, and start up drain pump of LP heater.
- 22) Start up two sets of primary air fan, put into coal mill operation.
- 23) When the turbine rotation speed reaches 3000rpm, shut down the AC lube oil pump, and pay attention to oil pressure change.
- 24) Inform the coordination and switch yard control to carry out synchronization soon. Close the isolator at main transformer outlet, check and close the isolator on the bus bar side. Close the grounding isolator at main transformer neutral point. Check the excitation regulation, close the excitation CB, and then start synchronization procedures after the conditions are satisfied.
- 25) After synchronization observe the turbine is with initial load. Set the target load to 80MW with gradient of 8MW/min, and increase the reactive power to 5Mvar. Adjust the excitation regulating mode, open or maintain the grounding isolator according to needs. Feed boiler fuel, control steam pressure and flow, and create conditions to put into coal powder and desuperheat water.
- 26) Warm up HP heater 1, 2, 3 and put into HP heater 3 gradually.
- 27) Open widely the reheater at cold- section of deaerator, pay attention to the pressure variation of cold reheater. Close the drain valve of reheater hot section.
- 28) Slowly adjust the desuperheat water to control the steam temperature. Try to switch the HP bypass to automatic control mode.
- 29) Put into more coal mills to create conditions for switching to HP cylinder.
- 30) After switching to HP cylinder, increase the load, close the drain valve of main steam, pay attention to the stress, and continue to put into coal mill operation.
- 31) Switch the power supply from auxiliary power to unit auxiliary transformer.
- 32) Check if the drain valves of the unit are all closed (120MW), and if the drain valves of pipes are all closed.
- 33) Put into HP heater 1, 2 gradually.
- 34) After all HP bypass are closed, put into boiler coordinated control.
- 35) Put into turbine load regulation.
- 36) When the condition (180MW) is satisfied, put into steam extraction stage 4 gradually, and switch the steam source of deaerator.

- 37) Start up coal mill, and stop oil burner.
- 38) When only 4 oil burners are left, put into ESP.
- 39) If the target load is more than 260MW, start up the second opened circulating cooling water pump.
- 40) When the load is more than 350MW or economizer inlet flow is high than 1000T/H, connect the second pneumatic feed water pump, and put the motor-operated pump into interlock standby, and put the two pneumatic feed water pumps into automatic control mode.
- 41) Stop the air heater.
- 42) Stop all the oil burners and oil pumps gradually.
- 43) Increase the load to the target load, and set the main steam temperature and reheat steam temperature to rated value.

8 Boiler Operation Adjustment

8.1 MCS Control System

8.1.1 Fuel Control System

Including control circuit of fuel, air of FDF, primary air pressure, primary air temperature, air box/furnace pressure difference, gas, and gas of IDF

Load adjustment

Normal load variation rate

- 1) Time for operation with varied voltage is 2.5%/min.
- 2) Time for operation with fixed voltage is 3%/min.
- 3) Normal load variation is allowed to last for 5 minutes, and then keep it for 5 to 10 minutes.
- 4) During normal load declining and steam pressure at boiler outlet is higher than the set value 5Kg/cm², the load of locked unit is decreasing.
- 5) During normal load raising and the steam pressure at boiler outlet is lower than the set value 10Kg/cm², the load of locked unit is increasing.

Maximum load variation rate

- 1) Time of operation with varied voltage is 3%/min.
- 2) Time of operation with fixed voltage is 5%/min.
- 3) During unit operation with varied voltage, the function relationship between set value of main steam pressure and the load refers to the provided thermal system balance chart.

It needs to operate at least two layers of nearby nozzles for boiler burner, if it is less than two layers of nozzles, and then there must be oil nozzle to assist combustion.

Primary Air Part

- 1) The function relationship between primary air and fuel quantity refers to the performance curve provided by the coal mill manufacturer
- 2) When the differential pressure of air duct and boiler furnace is lower than 635mmH₂O, the alarm of low primary air pressure is ringing.
- 3) When the differential pressure between primary air duct and furnace is less than 500mmH₂O, coal mill shall be shut down.

Secondary Air Part

- 1) Use auxiliary air damper to adjust the differential pressure between air box and furnace, the function relationship between load and the set value of the differential pressure between air box and furnace refers to the air performance design curve.
- 2) When the boiler load is less than 35%MCR, open the auxiliary air dampers at all layers. When the load is higher than 35%MCR, from the top to the bottom, close the auxiliary air dampers at upper and lower layers for the nozzles do not spread coal powder.
- 3) The damper of fuel air is controlled as per the fuel ratio. When this layer is stopping spreading coal powder, the damper of fuel air at this layer shall be closed at once.
- 4) The upper dampers of exhaust fuel air are controlled according to the load, when the load is 50~75%MCR, open the damper at layer 1, and when the load is 75~100%MCR, open the damper at upper layer.
- 5) During boiler MFT, open auxiliary air dampers and fuel air dampers at all layers.
- 6) For the auxiliary air dampers inserted with oil burner, during startup of the oil burners at this layer, close the auxiliary air dampers at this layer to the ignition position with opening of 35%.
- 7) When the differential pressure between air box and furnace is more than 230mmH₂O, the alarm will ring, at this time, open the all the auxiliary air dampers and fuel air dampers.

The boiler is required that the air quantity is ensured to be more than or equal to the fuel coal quantity under inner or outer interruption. The air lack is not allowed.

Furnace Negative Pressure

- 1) When the furnace negative pressure is less than -100mmH₂O, the alarm will ring. At this time, the locked ID fan opening increases and the FD fan air quantity decreases.
- 2) When boiler furnace negative pressure is more than +100mmH₂O, the alarm will ring. At this time, the locked ID fan opening decreases and the FD fan air quantity increase.

- 3) When the furnace negative pressure is less than -254mmH₂O, the boiler shall be disconnected.
- 4) When the boiler negative pressure is more than +330mmH₂O, the boiler shall be disconnected.
- 5) The furnace set value is related with the altitude of the measuring point, generally, -5mmH₂O is adopted.
- 6) When the boiler starts up and reaches 10MCR, the adopted fuel oil is light oil. When the oil pressure is less than 24Kg/cm² indicated on the pressure meter, the oil burner shall be disconnected; when the boiler operates with low load, the supporting fuel oil is heavy oil, and the output of boiler heavy oil system is 30%BMCR. When the oil pressure is less than 5Kg/cm² indicated on the pressure meter, then oil burner shall be disconnected.

Boiler required the lowest air flow is 30% of value under the boiler MCR.

Feed Water Control System

The feed water regulation adopts whole process regulation. When the boiler load is less than 10%MCR, adopt single stroke regulation, when the load is more than 10%MCR, adopts three-stroke regulation.

Feed water bypass regulating valve is a regulation means of feed water at the lowest rotation speed. During selection of the capacity of feed water regulating valve, it is required that there is no strong interruption during switching of the regulation mode from regulating valve to feed water pump.

Allowed range of controlled circulating boiler, alarm values and values of boiler shutdown are as follows:

Boiler type	allowed variation range (mm)	alarm value (mm)	boiler shutdown value (mm)
Controlled circulation	50	+127	+254
		-178	-381

Stage 1 and 2 superheat steam temperatures, and reheated steam temperature control

- 1) Superheat steam temperature regulation includes two stages of spray water regulation. The spray water stage one is as primary adjustment at the dividing screen inlet, the spray water stage two is the secondary adjustment which is located between the rear screen and end stage superheater. The design capacities: the water quantity spray water stage one is the 2/3 of the total spray water quantity, the water quantity of spray water stage two is 1/3 of the total spray water quantity.
- 2) The regulated parameter of spray water stage one is the steam temperature at the dividing screen outlet, and the regulated parameter of the spray water stage two is the steam temperature at superheater outlet.
- 3) The regulating of reheat steam temperature adopts swing burner regulation and spray water as emergency regulation. That is to say, the steam temperature rated value is 5℃ which is as the spray water regulation set value. The spray water point is located at the pipes of reheater inlet.
- 4) The lock of spray water pipes of superheater and reheater is used to ensure that spray water will not enter turbine to cause damage to turbine blades.

During boiler MFT, close the lock valve.

When boiler load is less than 20%MCR, close the lock valve.

When spray water regulating valve opening is more than 5%, the lock valve can be opened.

During boiler MFT, close the lock valve.

When boiler load is less than 20%MCR, close the lock valve.

When spray regulating valve opening is more than 5%, the lock valve can be opened

Relationship between temperature and load under fixed and sliding voltage conditions

5) Air preheater cold section regulation

In order to prevent air preheater from encrusting and corrosion, especially during boiler startup period, this regulation system shall be put into.

The set value of cold section temperature regulation: For fuel coal boiler, in order to prevent air preheater from low temperature corrosion, the recommended lowest average wall temperature of cold section:

Requirement:

$T_{Ai} + T_{GO}$

————— $> ACET$

2

in the formula: T_{Ai} — Average air temperature at air preheater inlet.

T_{GO} — Exhausted gas temperature (uncorrected value)

$ACET$ — Lowest average temperature of cold section

The cold section wall temperature control system shall be installed. The measured actual cold section average wall temperature at any time and under any load shall be higher than the lowest cold section average wall temperature (ACET), or else the air heater shall be put into. During boiler startup, put into air heater.

- 6) Control of the air flow at the coal mill inlet
- 7) Control of temperature at coal mill outlet
- 8) Control of deaerator pressure and water level
- 9) Control of water level of condenser
- 10) Control system of generator hydrogen temperature
- 11) Water level control system of HP, LP heater
- 12) Control of turbine bearing steam pressure and temperature
- 13) LP cylinder spray water pressure control
- 14) Turbine lube oil pressure and temperature control
- 15) Auxiliary steam pressure and temperature control

- 16) Condensate lowest flow control
- 17) Control of closed circulating cooling water temperature and water level of expansion water tank

8.2 Boiler Load Adjustment

There is another import part of MCS, the unit load command control. This control function creates load commands of the unit. These commdans will be sent to DEH and used to control the boiler fuel feeding and air feeding in order to realize energy balance between boiler and turbine.

8.2.1 Load Variation Rate

Normal load variation rate

- 1) Time of operation with varied voltage is 2.5%/min.
- 2) Time of operation with fixed voltage is 3%/min.
- 3) The normal load variation is allowed to last for 5 minutes, and then keep for 5 to 20 minutes.
- 4) During normal load decreasing and when the steam pressure at boiler outlet is higher than the set value 5Kg/cm², the load of locked unit is decreasing.
- 5) During normal load increasing and when the steam pressure at boiler outlet is lower than the set value 10Kg/cm², the load of locked unit is increasing.

Maximum load variation rate

- 1) Time of operation with varied voltage is 3%/min.
- 2) Time of operation with fixed voltage is 5% minutes.
- 3) During unit voltage variation, the function relationship between load and main steam pressure set value refers to the thermal system balance chart provided by turbine manufacturer.

There shall be at least two layers of nearby nozzles operating in the furnace. There shall be supporting oil nozzle if the quantity of nozzle is less than two layers.

8.2.2 Coordination Control of Turbine and Boiler

- 1) Boiler following method

Simply speaking, the characteristic of boiler following method is that turbine regulates the load value according to the coordination requirement, and boiler regulates the mian steam pressure and temperature by all means to make the steam pressure and temperature conform to the load. The control process chart refers to the figure 7-1.

The process: When the load vary with requirements, the turbine will adjust the main steam valve to regulate the input steam flow and to make the turbine output power conform to the load of the power grid. Because the steam flow change will cause the main steam pressure change, the pressure regulator adjust the boiler fuel coal quantity according to main steam pressure deviation in order to reduce the main steam pressure deviation. Along with the boiler regulator adjusting the fuel coal quantity, the air quantity, feed water quantity, and desuperheat water quantity will change in order to ensure parameters are in regulated range. This method can well satisfy the requirement of load variation, that is to say, the frequency regulation ability is improved. But the time delay of the boiler regulation, and large variation of steam pressure is bad for the stability of boiler combustion.

2) Turbine following method

Characteristic of turbine following method: When the load is changing, at first the boiler will regulate its combustion to make main steam pressure and temperature change in order to adapt to the requirement of load variation; then turbine will adjust the regulating valve to adjust the main steam pressure in order to make the load change correspondingly, and in order to meet the requirement of power grid load coordination. The control process chart refers to figure 7-2.

This control method is realized in this way: Boiler adjusts load, turbine adjust steam pressure, the main steam pressure fluctuates little, and the load adapting time is short. But this method is bad for the requirement of power grid coordination.

3) Coordinate control method

When outer load is changing, unit power deviation value and the main steam pressure deviation value act on the boiler and turbine main controller through coordinate controller to adjust the load. The process chart refers to the figure.

Characteristic of coordinate control method: The coordination of oiler feed water, air flow, turbine steam flow, main steam pressure are going on at the same time. Within the regulated boiler steam pressure variation range, fully utilize the boiler heat storage ability to adapt to turbine needs. This can not only ensure the excellent load adaptability, but also ensure stability of boiler parameters.

8.3 Boiler Control Plan

Boiler main control sends out turbine load control demands according to unit main control system to make the generator power meet requirements.

At the same time, load and mian steam pressure signal create a complete control, boiler output (feed water, fuel, air

and etc.) as boiler input demand signal (BID) to make main steam pressure at set value.

Boiler main control is composed of BF pressure regulator, coordinate boiler regulator, and boiler main control M/A station.

Under BF mode, BF regulator receives front unit pressure deviation signal, after calculation of PID and front feedback energy signal plus boiler pressure derivative signal, finally sends out boiler main control in BF mode.

Under coordinate mode, boiler side coordinate regulator receives comprehensive actions of front unit pressure deviation and load control deviation, after PID calculation and dynamic thermal energy requirement feedback decided by its output and load plus main steam pressure preset derivative feedforward of corrected preset load and main steam pressure derivative feedforward, then finally send out boiler main control demand in coordinate mode.

Boiler BF regulator and boiler regulator in coordinate mode, under work condition (or not under BF mode or DEB mode), will automatically trace the output boiler main control demand from main control actuator. So the process of boiler controller switching from manual control mode to BF mode or coordinate control mode is process without balance or interruption.

8.3.1 The Conditions of Boiler Main Control Switch to Manual

When the any of the following conditions occurs, boiler main control will switch to manual control compulsively:

- 1) Main steam pressure signal sending fault occurs.
- 2) Under coordinate control mode, the generator power signal receiving fault occurs.
- 3) Under BF mode, pressure output fault occurs in speed governing grade.
- 4) Feed water pump are all under manual control mode.
- 5) RUN BAKE
- 6) ATC requires reducing load for 50%.
- 7) Coal main control is under manual control mode.
- 8) Boiler MFT;
- 9) Two FD fans are under manual control mode.
- 10) Two ID fans are under manual control mode.
- 11) Two primary air fans are under manual control mode.

8.4 Boiler Sequence Control and Interlock

Boiler sequence control and interlock contents include the functions like the control, interlock, protection and operation of main auxiliary equipments, equipments and systems of boiler system.

It is designed to be a graded structure with three grades of function group grade, sub-function group grade, and driving grade.

8.4.1 The Main Protector of Boiler Interlock

The boiler interlock protection mainly covers the protections of the following auxiliary equipments:

- 1) Air preheater
- 2) ID fan
- 3) FD fan
- 4) Primary air fan
- 5) Coal mill
- 6) Coal feeder

8.4.2 The Subsystems of Boiler Interlock

Boiler interlock control includes the following subsystem:

- 1) Startup permitted
- 2) Logic trip

8.5 Security Protection of Boiler

- 1) Over pressure protection of main stream pressure
- 1) Fuel cut protection
- 2) Furnace pressure protection
- 3) Reheater steam over temperature protection
- 4) Feed water flow low protection
- 5) Reheat steam pressure low protection
- 6) Boiler fire-extinguishing protection

8.6 Combustion Control

Boiler burner needs at least two layers of nearby operating nozzles, or else there shall be supporting oil nozzle.

8.6.1 Primary Part

- 1) Function relationship between primary air and fuel quantity as per the performance curve provided by coal

mill manufacturer.

- 2) When the differential pressure of primary air duct and furnace is less than 635mmH₂O, the alarm of primary air low will ring.
- 3) When the differential pressure of primary air duct and furnace is less than 500mmH₂O, coal mill shall be shut down.

8.6.2 Secondary Air Part

- 1) Use auxiliary air damper to adjust the differential pressure of air box and furnace. The function relationship of the differential pressure of air box and furnace refers to the air fan performance design curve.
- 2) When the boiler load is lower than 35%MCR, the auxiliary air damper at all layers shall be opened. When the load is higher than 35%MCR, from the top to the bottom, close the auxiliary air dampers at upper and lower layers for the nozzles do not spread coal powder.
- 3) The damper of fuel air is controlled as per the fuel ratio. When this layer stopping spreading coal powder, close the damper of fuel air at this layer at once.
- 4) The upper dampers of exhaust fuel air are controlled according to the load, when the load is 50~75%MCR, open the damper at layer 1, and when the load is 75~100%MCR, open the damper at upper layer.
- 5) During boiler MFT, open auxiliary air dampers and fuel air dampers at all layers.
- 6) For the auxiliary air dampers inserted with oil burner, during startup of the oil burners at this layer, close the auxiliary air dampers at this layer to the ignition position with opening of 35%.
- 7) When the differential pressure between air box and furnace is more than 230mmH₂O, the alarm will ring, at this time, open the all the auxiliary air dampers and fuel air dampers.
- 8) The boiler is required that the air quantity is ensured to be more than or equal to the fuel coal quantity under inner or outer interruption. The air lack is not allowed.

8.7 Steam Temperature Adjustment

Stage 1 and 2 superheat steam temperatures, and reheated steam temperature control

Superheat steam temperature regulation includes two stages of spray water regulation. The spray water stage one is as primary adjustment at the dividing screen inlet, the spray water stage two is the secondary adjustment which is located between the rear screen and end stage superheater. The design capacities: the water quantity spray water stage one is the 2/3 of the total spray water quantity, the water quantity of spray water stage two is 1/3 of the total spray water quantity.

The regulated parameter of spray water stage one is the steam temperature at the dividing screen outlet, and the regulated parameter of the spray water stage two is the steam temperature at superheater outlet.

The regulation of reheat steam temperature adopts swing burning. The spray water is as manual protection. That is to say, the steam temperature rated value is 5℃ which is as the spray water regulation set value. The spray water point is located at the pipes of reheater inlet.

The lock of spray water pipes of superheater and reheater is used to ensure that spray water will not enter turbine to cause damage to turbine blades.

During boiler MFT, close the lock valve.

When boiler load is less than 20%MCR, close the lock valve.

When spray water regulating valve opening is more than 5%, the lock valve can be opened.

During boiler MFT, close the lock valve.

When boiler load is less than 20%MCR, close the lock valve.

When spray regulating valve opening is more than 5%, the lock valve can be opened.

8.8 Steam Pressure Adjustment

The steam pressure adjustment has different control mode according to CCS status. Details refer to 8.2.2.

8.9 Feed Water Adjustment

Feed water control system

The feed water regulation adopts whole process regulation. When the boiler load is less than 10%MCR, adopt single stroke regulation, when the load is more than 10%MCR, adopts three-stroke regulation.

Feed water bypass regulating valve is a regulation means of feed water at the lowest rotation speed. During selection of the capacity of feed water regulating valve, it is required that there is no strong interruption during switching the regulating mode from regulating valve to feed water pump.

Allowed range of controlled circulating boiler, alarm values and values of boiler shutdown are as follows:

Boiler type	allowed variation range (mm)	alarm value (mm)	boiler shutdown value (mm)
Controlled circulation	☐ 50	+127	+254
		—178	—381

8.10 Boiler Blowdown

8.10.1 Continue Blowdown Flow Control

Conditions for switching from control circuit manual to manual control

- 1) Continue blowdown flow signal is disabled.
- 2) Set value is quite different from measured value.
- 3) Demand and feedback is quite different.
- 4) The feedback from the position is bad quality.

Water level control of boiler continue blowdown flash tank.

Adjust the opening of the regulating valve of continue blowdown flash tank to adjust the water level of boiler continue blowdown flash tank.

8.10.2 Boiler Intermittent Blowdown

Boiler intermittent blowdown is a sequence control program. First open the motor-operated main valve of intermittent blowdown, then open the motor-operated branch valves of intermittent blowdown one by one, and close the motor-operated main valve.

9 Shutdown and Maintenance of Boiler

9.1 Boiler Normal Shutdown

9.1.1 Preparation Works before Boiler Shutdown

After receiving the demand of preparation for unit shutdown, the shift leader will inform the planned shutdown time to the personnel of central control, fuel operation, ash handling, and chemical posts, and inform the arrangement and requirements of boiler shutdown, in order to make good preparation before boiler shut down.

- 1) Coordinate the central control leader to switch the steam supply from auxiliary steam supply to nearby boiler steam supply or to startup steam supply.

Carry out test run on AC auxiliary oil pump for BTG, DC emergency oil pump for BTG, AC startup oil pump, jacking oil pump, and motor of barring gear, and confirm that they are normal and at automatic position. If the test run is not qualified, under non-breakdown shutdown condition, the shutdown shall be delayed and the boiler cannot be shut down after the faults are eliminated.

- 2) Confirm that the DEH control mode is in AUTO mode.

- 3) According to the allowed load reducing rates of “Shutdown Curve with Sliding Pressure” and boiler, the small load value will be selected as the load reducing rate limit of the unit.
- 4) Make overall records of primary steam temperature and metal temperature. Then from the load reducing, make record once every an hour during load reducing till the barring gear is stopped normally.
- 5) Inform the unit shutdown requirements and arrangements to personnel at posts of coal handling, ash handling, and chemical water to make preparation for unit shutdown. The fuel oil storage shall meet the requirement of unit shutdown.
- 6) If unit shutdown duration time is over seven days, the coal in all coal bunkers shall be burned out before boiler shutdown. Inform the coal operator to control the coal in coal bunker to be at a proper level.
- 7) Before boiler shutdown, put into oil burner once for testing. After the oil burner being normal, switch it to standby status.
- 8) Before load reducing, carry out overall soot blowing once on boiler heating surfaces (including air preheater)
- 9) Carry out overall check of all auxiliary equipments and make record of the defects.

9.1.2 Boiler Shutdown

- 1) Inform operator at all posts to carry out an overall check of all auxiliary equipments and systems and make records of the found defects.
- 2) The shift leader shall decide whether all the fuel coal in coal bunker shall be burned out.
- 3) Carry out an overall check of front boiler fuel oil system before boiler shutdown. All the oil burners shall be put into once for testing according to actual conditions to check whether it is normal and in good standby status. The fuel oil storage quantity shall meet the requirement of boiler shutdown.
- 4) When the unit load is at 480MW, overall soot blowing of all heating surfaces shall be carried out once.
- 5) Make an overall record of steam temperature and metal temperature once, and make a record of boiler expansion value once.
- 6) Start to reduce the pressure and load as per the requirements of “Turbine and Boiler Sliding Shutdown Curve”. The load variation rate shall not be higher than 12MW/min under control. Main steam pressure variation rate shall not be higher than 0.5 MPa/min under control.
- 7) After burning out the fuel coal in the coal bunker of one coal mill, this coal mill shall be shut down, while other four coal mills remain operating. During load reducing, the E coal powder system at the upper front wall shall be shut down at first, and then the B coal powder system shall be shut down.
- 8) When the load reaches 350MW, continue to burn out the coal in the coal bunker of coal mill D, and then shut down coal mill D, while other three operating coal mill.

- 9) When the load is 300MW, main steam temperature is 520°C, and reheat steam temperature is 540°C, the igniting oil burner shall be put into according actual conditions or plasma igniter shall be burned stably.
- 10) When the load is reduced from 300 MW to 180MW, the load reducing rate shall not higher than 5MW/min.
- 11) During temperature and pressure reducing process, main steam temperature shall keep stable for 10 minutes whenever temperature reducing reaches 30°C, in order to control the temperature between difference main steam and reheat steam and the expansion difference between HP cylinder and LP cylinder.
- 12) When load is 250MW, a layer of oil burner shall be put into according to boiler combustion conditions. The F coal powder system can be shut down during load reducing process. Before coal mill shutdown, in order to ensure stable combustion, the igniting oil burner of two operating coal mill can be put into or plasma igniter can be put into.
- 13) Continue to reduce the load, the air preheater shall put into continue soot blowing mode.
- 14) The load is 180MW, main steam temperature is 500°C, reheat steam temperature is 500°C.
- 15) Confirm that the auxiliary power supply is switched to startup & standby transformer.
- 16) Switch the steam supply from the unit to auxiliary steam header, and confirm that the auxiliary steam system operates normally, and the steam pressure regulating valve of cold reheat to unit auxiliary steam is closed.
- 17) After load is reduced to 180MW, start up the motor-operated feed water pump, and shut down another pneumatic feed water pump.
- 18) Reduce load to 150MW, keep operation of one layer of igniting oil burner and a coal mill till the coal level of the coal bunker of this mill is low, then start the preparation of the clearing of the last mill. Inform the operators for auxiliary equipments to shut down the ESP.
- 19) During load reducing period, pay attention to drum water level monitor.
- 20) The load is reduced to 120MW, main steam temperature is 480°C, and reheat steam temperature is 480°C.
- 21) Open HP and LP bypass and coordinate main steam pressure according to actual conditions.
- 22) Continue to reduce the load to 60MW. And the main steam temperature is 450°C, and the reheat steam temperature is 450°C.
- 23) During load reducing period, the feed water flow shall be higher than 410t/h at any time before boiler fire-extinguishing.
- 24) The last coal mill shall be blown to be empty. The active power is reduced to 40MW below, and reactive power is reduced to 50MVar below.
- 25) After turbine is tripped, pay attention to generator reverse power disconnection conditions and the turbine rotation reducing.
- 26) Confirm that the plasma igniter is tripped and primary air fan and sealing air fan are tripped too.

- 27) Boiler fire is extinguished, and MFT action result is ensured to be normal.
- 28) After boiler normal sliding shutdown, keep the operation of motor-operated feed water pump and the heating of deaerator. After boiler water feeding at low flow for a period, shut down the motor-operated valve.
- 29) Carry out soot blowing at 35%MCR flow for 5 minutes, then disconnect front boiler fuel oil system after soot blowing.
- 30) Stop FD fan and ID fan.
- 31) Check and ensure the boiler access doors, flam observation hole and dampers of air ducts and gas ducts are closed, and then extinguish fire in boiler.
- 32) Make sure that the desuperheat water isolating valves and regulating valves of superheater and reheater are closed. Close the manual valves of desuperheat water system of reheater and superheater.
- 33) Make sure that the quick close valves of fuel oil pipe and oil feeding valves of oil burner are closed. Isolate the front boiler fuel oil system, and close the front boiler oil supply and return oil manual main valves.
- 34) Close the sampling manual valve of boiler steam water system.
- 35) When boiler needs to warm up and discharge water, after the steam pressure at steam-water separator outlet is reduced to 0.6MPa and water wall outlet temperature is lower than 180℃, all the discharge valves can be opened to discharge water, and all the vents can be opened.
- 36) When main stream pressure is ≤ 0.2 MPa, open the air vent at high temperature superheater outlet, the air vent at high temperature superheater inlet, the air vent at low temperature superheater outlet, the air vent at low temperature superheater inlet, and the air vent at roof superheater.
- 37) After boiler water discharge, the natural ventilation at the boiler bottom shall be broken.
- 38) After the gas temperature at air preheater inlet is reduced to 150℃ below, the air preheater can be started to operate.
- 39) After gas temperature at furnace outlet is reduced to 50℃ below, the flame scanner cooling air fan can be shut down.

9.2 Emergency Shutdown of Boiler

9.2.1 Conditions for Boiler Emergency Shutdown

- 1) MFT missing operation
- 2) Feed water pipes or steam pipes crack which endanger human and equipments.
- 3) Boiler pressure bearing parts, heating surface tubes, or pipes cracks and cannot be repaired.
- 4) All boiler feed water level indicator are broken, which cause the boiler water feed cannot be monitored.

- 5) Boiler fuel oil pipe explodes, or oil system catches fire, and isolation cannot be implemented so as to endanger human and equipments.
- 6) Front wall cracks or steel structure or steel beam is burned into red color.
- 7) Combustion occurs in backpass, or exhausted gas temperature raises sharply and reaches 250 °C.
- 8) Boiler pressure rise exceeds the set value of safety relief valve, which causes safety missing operation.
- 9) Safety relief valves of superheater and reheater did not return to the valve seat after action, which causes steam pressure of superheater and reheater reduces and makeup water quantity cannot maintain operation.
- 10) Explosion occurs in furnace or gas duct, which brings serious damage to equipments.
- 11) Accident endangered human safety happened, and the boiler needs to shut down.

9.2.2 Operations:

- 1) Press “emergency trip” button manually, shut down the unit through BTG interlock.
- 2) Check if the interlocks of boiler, turbine, and generator act correctly, or else manually trip the unit.
- 3) Confirm that boiler quick close valves of oil supply and return oil are closed, and the fuel small circulating valve is opened.
- 4) Confirm that igniting valve of fuel oil burner is closed, oil burner purging is locked, and oil burners are quit.
- 5) Confirm FD fans and ID fans are switched to manual control and adjust the negative pressure of furnace.
- 6) Confirm that all mills, primary air fans, sealing air fans are tripped, valves of coal powder system act normally.
- 7) Confirm that the check valves and regulating valves of desuperheat water stage one and stage two and emergency spray water are closed.
- 8) Check if air preheater operates normally, or else start up auxiliary motor operation.
- 9) Check if flame scanner cooling air fan operates normally, or else start up standby flame scanner cooling air fan.
- 10) Make clear the causes of the accident, and report it to the superior.

9.3 Boiler Shutdown and Maintenance

Boiler warming up, water discharge, and vacuum dry method

9.3.1 Purpose of Boiler Shutdown and Maintenance

Make the metal surface of boiler water-steam system after boiler shutdown for more than one week, in order to

prevent corrosion of water-steam system during boiler shutdown.

9.3.2 Responsibility

Manager in charge of overhaul: If the planned time for boiler outage for maintenance is over one week, the comments of related parties (engineering and mechanical department, people in charge of boiler maintenance, power generation department, and chemical department) shall be collected to decide which method will be used to carry out boiler protection during boiler outage.

Engineer on duty: If the planned time for boiler outage is over one week, the chemical and I & C personnel shall be organized to carry out boiler protection during boiler outage according to the boiler warming up, water discharge and vacuum dry method specified in this document. And report to manager of power generation department.

Operator on duty: According to operations specified in this document, the operators on duty carry out isolation and recovery of instruments and meters in attachment No.2.

I & C personnel: to carry out temporary vacuum meters as required, force and release signal, and carry out isolation and recovery of instruments and meters in attachment No.1.

Chemical personnel: Make record of pressure in temporary vacuum meter, to decide the terminal time of vacuum dry method and coordinate relative personnel to check the effect of vacuum dry.

9.3.3 Technical key Points for Boiler Warming up Water Discharge Vacuum Dry Method

The effect of vacuum dry is determined by the tightness of the system.

Before water discharge boiler compulsive cooling shall be stopped. When drum pressure reaches 5 bar and the differential metal temperature of drum temperature at different points is lower than 120℃, discharge boiler water promptly. During water discharge process, open exhaust valve, water valve, and water discharge valve, and close exhaust valve, drain valve, manual valve and motor operated valve for water discharge.

Start HP bypass and LP bypass, use condenser vacuum extraction system to extract vacuum of reheater, superheater, boiler proper and economizer.

When turbine pressure meter indication reaches 0.05Mpa, continue to extract vacuum for 4 to 6 hours. During vacuum extraction process, the steam drum pressure meter indication shall be controlled within -0.05~-0.075 Mpa by startup and shutdown vacuum pump (pay attention to startup times) and adjustment of opening LP bypass regulating valve.

After finishing vacuum extraction, manager in charge of overhaul will decide whether and when to restart boiler compulsive cooling.

9.3.4 Systems Received Vacuum Dry

Vacuum pump, condenser, LP bypass, reheater, HP bypass, superheater, boiler proper, and economizer

9.3.5 Preparation before Vacuum Dry

Close all the pressure meters, pressure transmitters, and primary and secondary valves of other instruments in vacuum dry system, which are not allowed to work under vacuum condition, in order to avoid damage. After finishing vacuum dry and break the vacuum, all those shall be recovered to the original status.

Install a vacuum meter on the top of drum.

During vacuum extraction process, if the system is not tight, all the drain valves, manual and motor-operated valves for water discharge shall be closed.

9.3.6 Operation Procedures

Turbine startup and shutdown will be carried out as per normal startup and shutdown procedures.

Operation procedures of boiler warming up and water discharge

- 1) After boiler shutdown, try to keep drum water high level to decrease the differential temperature of upper and lower drum walls. Boiler cooling and water discharge will be carried out as per article 3.1 and 3.4.
- 2) When drum pressure declines to 0.5Mpa and the maximum differential metal temperature is $\leq 130^{\circ}\text{C}$, the water inside the boiler shall be discharged promptly. During steam drum pressure declining and water discharge process, the differential wall temperature between two points shall not exceed 500°C , and the drum water discharge procedures are as follows:
- 3) Open reheater air vent
- 4) Open boiler manual valve of continue blowdown, boiler water discharge manual valves at the boiler bottom and water discharge manual valves at economizer.
- 5) And open motor-operated valve of boiler continue blowdown, motor-operated water discharge valve at boiler bottom, and motor-operated water discharge valve. Open the header before boiler water pump to discharge water in order to speed up boiler water discharge.
- 6) Open drain valve of superheater.
- 7) When drum pressure is reduced to 0.2Mpa, the drum exhaust valve shall be opened.
- 8) Open drain valve of desuperheat water pipes of superheater. Check and ensure desuperheat water motor-operated valve is in closed status.
- 9) Open drain valve of desuperheat water pipes of superheater to discharge water.

- 10) When drum pressure reaches 0-0.1 Mpa, the water discharge valve at the pipes of intermittent blowdown and boiler bottom, in order to discharge all the water in pipes.
- 11) If only carry out boiler water discharge method to protect the boiler during boiler outage, after finishing boiler water discharge, under normal condition the air vent, exhaust valve, and water discharge shall be closed to close the boiler. If there is boiler maintenance work, the above valves can be opened if necessary.

Isolation work of valves before vacuum dry

When there is no water flowing out from the water discharge valves of intermittent blowdown pipes and boiler bottom pipes, the following valves shall be closed:

Close reheater air vent.

Close drain valve of superheater.

Close water discharge valves of intermittent blowdown and boiler bottom.

Close the water discharge valve of header in front of boiler water pump.

Close water discharge valve of economizer.

Close drum exhaust valve.

Close drain valve of superheat water pipe of superheater, and close motor-operated valve of desuperheat water.

Close drain valve of desuperheat water pipe of reheater.

Close water discharge valve of water discharge pipe of intermittent blowdown and boiler bottom.

Close valve of intermittent blowdown.

Close manual isolating valve of soot blower.

Close drain valves of main steam and reheat steam pipes.

Confirm that drain valve of reheater is closed.

Close boiler water sampling valve.

Close saturated steam sampling valve.

Close superheat steam sampling valve.

Close reheat steam sampling valve.

Confirm that motor-operated valves of boiler main/auxiliary feed water are closed.

Close all the pressure meters, pressure transmitters, and primary and secondary valves of other instruments in vacuum dry system, which are not allowed to work under vacuum condition, in order to avoid damage, and sign on instrument isolation list.

Procedures of vacuum extraction

Start up condenser as normal startup procedures in order to create vacuum. During turbine shutdown, condenser is

allowed to remain it vacuum degree according to operation conditions to remain condenser vacuum status. During the whole vacuum dry process, the circulating water pump shall keep operating.

Coordinate I & C personnel to force HP bypass desuperheat water signal compulsively in order to open HP bypass and LP bypass (to prevent desuperheat water from opening).

Make record of vacuum degree once every 1 to 5 minutes.

When drum pressure meter indication reaches -0.050Mpa , continue to extract vacuum for 4 to 6 hours. During vacuum extraction process, the pressure indication shall be controlled within $-0.05\sim-0.075\text{ Mpa}$ through startup and shutdown vacuum pump (pay attention to startup times) and adjustment of opening of LP regulating valve.

I & C personnel decide whether to stop the vacuum extraction.

After vacuum extraction, generally, the air vent, exhaust valve and water discharge valve shall be closed to close the boiler. If there is boiler maintenance work, the above valves can be opened if necessary.

Close HP and LP bypass, and recover HP desuperheater water signal.

Recover the isolated instrument and sign on instrument isolation list.

9.3.7 Inspection of Dry Effect

If available, I & C personnel lead the vacuum dry effect.

After finishing vacuum dry, open access door at lower header to check if there is water at header bottom, and measure relative humidity of air inside the header.

Cut down the elbow of superheater or reheater to check if there is water inside.

After unit startup, monitor the Fe content in steam-water.

10 Accident Handling of Boiler

10.1 Accident Handling Principles

10.1.1 Accident Handling Principles

- 1) When accident happens, accident handling shall follow the principles of “ensure the safety of human, power grid, and equipments”.
- 2) During accident handling process, operators shall ensure the normal operation of auxiliary power system.

10.1.2 Key Points during Accident

- 1) Find out accident location according to indications on instruments and abnormal phenomena.

- 2) Handle the accident promptly, and remove the danger of human, power grid, and equipments. Every accident handling stage shall be reported to the shift leader, central controller, and relative responsible people on site, in order to take counter measures promptly and correctly so as to prevent accident spreading.
- 3) If necessary, the breakdown equipments shall be tripped or disconnected to ensure normal operation of other normal equipments.
- 4) Find out causes and eliminate the accident.
- 5) When handling the accident, personnel on all post shall inform actual conditions to each other under the leadership of the shift leader. The orders from shift leader shall be strictly implemented except for those endangers human or equipments.
- 6) During fault handling, operators shall repeat the received demand once, and if he didn't hear the demand clearly, he shall ask and make it clear at once. The operation shall be correct and prompt. After the demand is implemented, operators shall report it to the shift leader.
- 7) People in charge of operation department, special engineers, and safety supervisor shall go to site to assist the shift leader to carry out accident handling, and to supervise the accident handling. But the demand from them shall not be conflicted with the demand from the shift leader.
- 8) If the accident happened during handover between two shifts, the handover shall be stopped, and the original shift shall carry out accident handling, and the new shift can assist the accident handling after being permitted by the original shift. And the handover will be carried out after accident handling.
- 9) The people not involved in accident handling are prohibited to stay at the accident location.
- 10) After accident happened, I & C personnel shall arrive at site to make record of relative conditions and parameters which may be used to analyze the accident.
- 11) After accident handling, the shift leader, central controller, operators on duty shall make correct and detailed record of fault phenomena, fault development process and duration time, fault counter measures.

10.2 Low Water Level of Boiler

10.2.1 Phenomena

- 1) LCD is alarming, and drum water level is low.
- 2) Local water level indicates low.
- 3) Emergency louder speaker is alarming.

10.2.2 Causes:

- 1) Feed water automatic regulation is disabled.
- 2) Feed water pump breaks down, feed water flow decline.
- 3) Water wall or economizer leaks.
- 4) Steam pressure fluctuation is large.
- 5) Water level indication is not correct, which cause mis-operation of operators.
- 6) Misoperation of boiler blowdown operation
- 7) The monitor of water level during feed water manual control is not strict or mistakenly operated.

10.2.3 Handling:

- 1) First, check if the indication of water level indicator is correct or not, and take counter measures after confirm its correctness.
- 2) If feed water automatic control is not satisfied, switch it to manual control to increase feed water quantity.
- 3) If the feed water pump is tripped, the fuel supply shall be tripped at once to prevent boiler dry burning.
- 4) If the boiler is carrying out blowdown, the blowdown valve shall be closed immediately to stop blowdown.
- 5) If boiler heating surface leaks, report it to the shift leader at once.

Preventions of low water level of drum

- 1) In order to ensure the correctness of the indications on water level indicators of steam drum, every shift shall check the indication on local water indicator and the indication in central control room twice. When water level indication is not correct, report it to the I & C personnel to repair.
- 2) During boiler operation, pay attention to steam drum water level monitor.
- 3) When the water level control is switched to automatic control mode, pay attention to feed water regulating valves and ensure that they are flexible and normal. If the automatic control is not satisfied,
- 4) Load increase and decrease shall be carried out slowly with even adjustment of combustion rate. It is prohibited to put into 2 or more oil burners at one time or to start up or shut down coal mill continuously.
- 5) Manual control of water level shall be even and stable, it is prohibited to quick close or open the regulating valve so as to cause tripping of feed water pump.
- 6) The offset of boiler blowdown shall be well planned. It is prohibited to carry out blowdown of upper drum, lower drum, and water wall lower header at the same time.
- 7) Coordinate with shift leader to prevent steam quantity change suddenly or cause large fluctuation of steam pressure.

- 8) Reinforce monitor of water level of makeup water tank; contact chemical to feed water when water level is low to prevent low water level of feed water pump cause feed water pump tripping.

10.3 High Water Level of Boiler

10.3.1 Phenomena:

- 1) LDD is alarming.
- 2) Drum water level is high.
- 3) Emergency louder speaker is alarming.

10.3.2 Causes:

- 1) Feed water automatic adjustment is disabled.
- 2) Steam pressure fluctuates violently.
- 3) Water level indication on water level indicator is not correct, which cause mis-operation of operators.
- 4) Monitor of water level during feed water automatic control is not strict or mis-operation occurs.

10.3.3 Handling:

- 1) Check if the indications on water level indicators are correct or not, and go to check the local water level indication. Take counter measures after confirm the correctness of water level.
- 2) If feed water automatic control is not satisfied, switch it to manual control to reduce feed water quantity.
- 3) Open drum emergency discharge motor-operated valve.
- 4) If it is caused by pressure fluctuation, it can be adjudged as fake water level, so it is no necessary to reduce much feed water quantity.
- 5) If drum water level increases to the high point of water level indicator (upper limit 250mm) , the boiler shall be shut down emergently and stop steam supply.

10.4 Water Wall Leakage

10.4.1 Phenomena:

- 1) Drum water level declines, and drum pressure declines too.
- 2) Feed water flow is abnormally higher than the steam flow, chemical makeup water increases.
- 3) There is loud sound in water wall during explosion.

- 4) The combustion inside the furnace is not stable, the flame brightness weakens.
- 5) FD fan inlet damper is turned down, the current declines.
- 6) Gas temperature declines.

10.4.2 Causes:

- 1) Boiler water quality is not qualified, which makes the pipe encrust and brings damage to pipes because of overheat.
- 2) Boiler input water control is not proper.
- 3) The manufacture and welding of pipes are not qualified.

10.4.3 Handling:

- 1) When the leakage of water wall pipes is not serious, reinforce the feed water to maintain drum water wall, and maintain stable combustion through strict monitor of the fault point.
- 2) When leakage is serious and the drum water level cannot be maintained, the boiler shall be tripped emergently.
- 3) Maintain the operation of FD fan and ID fan, and stop them after the steam is completely exhausted.
- 4) After boiler shutdown and the drum water level can be maintained, it is prohibited to feed water to boiler. It is prohibited to open recirculation valve of economizer.

10.4.4 Prevention:

- 1) The water quality shall be controlled strictly to prevent water wall encrusting.
- 2) Boiler water feeding shall be carried out strictly as per relative regulations.
- 3) Well organize the oil burner combustion to prevent water wall from being burned down by secondary combustion.

10.5 Leakage of Superheater and Reheater

10.5.1 Phenomena:

- 1) Main steam pressure declines.
- 2) Feed water flow is higher than steam flow abnormally, and chemical makeup water quantity increases.
- 3) There is abnormal sound near leakage place, and gas temperature declines at the leakage point.
- 4) FD fan inlet regulating damper is turned down, current declines, burning of oil burner weakens.

10.5.2 Causes:

- 1) Steam quality is unqualified for quite a long time, which causes corrosion and damage of pipes.
- 2) Manufacture and welding quality of pipes are not qualified.
- 3) Drum water overflows, which causes the heat stress of pipes is too strong, and pipes are overheat for a long time.

10.5.3 Handling:

- 1) When leakage of pipes of superheater and reheater is not serious, reinforce water feeding to maintain drum water level. Maintain stable combustion, and reinforce monitor of fault points. Report it to shift leader and make good preparation of boiler shutdown.
- 2) When the leakage is serious, the boiler shall be shut down at once.

10.5.4 Prevention:

- 1) Control steam temperature to prevent over temperature during operations of reheater and superheater.
- 2) Control steam quality.

10.6 Combustion in Boiler Backpass

10.6.1 Causes:

- 1) Atomization of fuel oil is not good.
- 2) Ratio of air and oil is too low, combustion is not complete.
- 3) Air flow is too large, and the oil burning time in furnace is too short.
- 4) The access door or dirty oil discharge valve is not closed, or the sealing of boiler bottom is not tight, so that a lot of cool air comes into the furnace, which causes the low temperature, higher flame center and incomplete combustion in furnace.
- 5) There is leakage on furnace heating surface, which causes low temperature in furnace.

10.6.2 Handling:

- 1) If the gas temperature at boiler backpass is abnormally rising (the temperature at ID fan inlet), the correctness of the indications on meters shall be checked.
- 2) If confirmed that it is combustion in boiler backpass, the boiler shall be shut down emergently.

- 3) Stop operation of boiler ID fan, stop the regulating dampers at FD fan inlet, regulating damper at ID fan inlet, isolating damper at ID fan outlet, and main air valve of oil burner.
- 4) Close motor-operated valve at superheater outlet, open drain valve at superheater outlet, maintain boiler pressure, and open the steam motor-operated valve to input steam for oil burner purging.
- 5) When gas temperature is lower than 150°C, keep it for an hour, then open the inspection door to carry out inspection.
- 6) Check if there is fire source, and then start ID fan to exhaust the gas inside the gas duct. When the temperature declines to 50°C below, the remained dirt and unburned oil shall be cleared.
- 7) Immediately inform relative departments and superiors.

10.6.3 Prevention:

- 1) After boiler normal operation, oil burner extinguishing protection shall be put into.
- 2) Check oil burner combustion status, and regulate it whenever it is not good.
- 3) During putting into or quitting oil burner, the principle shall be followed that the air shall be put into first then the oil shall be put into later, and the oil shall be reduced first then the air shall be reduced later.
- 4) Improper atomization of oil burner may be caused by improper oil pressure. This problem can be solved by adjusting the oil pressure. If the effect by oil pressure adjustment is not obvious, the problem may be caused by fault of atomization sheet of atomizer. So carry out steam purging on oil burner or change the broken atomization sheets.
- 5) According to fuel oil pressure, fuel oil quantity to adjust the air flow of oil burner and to adjust cyclone strength of oil burner so as to achieve the best air and oil ratio, in order to ensure proper combustion with bright flame.

10.7 Boiler Manual Emergency Shutdown

10.7.1 Boiler Manual Emergency Shutdown

- 1) MFT missing operation
- 2) Feed water pipes or steam pips crack and endanger the safety of human and equipments.
- 3) Boiler pressure bearing parts, heating surface pipes, or pipes explode and cannot maintain boiler operation.
- 4) Feed water flow meters of boiler are broken, so the boiler water feed quantity cannot be monitored.
- 5) Boiler fuel oil pipes explode or oil system catches fire, and the human and equipments can are endangered and cannot be isolated.

- 6) Furnace water cracks and steel structure or steel beam is burned into red color.
- 7) Combustion occurs in boiler backpass, or exhausted gas temperature increase sharply and exceeds 250 °C.
- 8) Boiler pressure raises and exceeds the set value of safety relief valve, but all the safety relief valve is missing operation.
- 9) The safety relief valves of main and reheat steam does not return to the valve seat after action, and causes pressure of main and reheat steam declines, and makeup water cannot maintain boiler operation.
- 10) Explosion occurs in furnace or gas duct and causes serious damage to equipments.
- 11) When emergency accident happens and need to shut down the boiler emergently

10.7.2 Specific Operation Procedures:

- 1) Immediately press “emergency trip” button to shut down the unit through BTG interlock.
- 2) Check the correctness of interlock actions of BTG, or else manually trip the unit.
- 3) Confirm that boiler oil supply valve and oil quick close valve are closed, and open fuel oil small circulating valve.
- 4) Confirm that the igniting valve of fuel oil burner is closed, the oil burner purging is locked, and the oil burner is quit.
- 5) Confirm that the FD fan and ID fan is switched from automatic control mode to manual control mode to adjust the negative pressure of furnace.
- 6) Confirm that mill, primary air fan and sealing air fan are tripped, and actions of valves in coal powder system are correct.
- 7) Confirm that stop valves of primary and secondary desuperheat water, emergency spray valve, and regulating valve is closed.
- 8) Check if air preheater operates normally, or else stat up auxiliary motor operation.
- 9) Check if fire detecting cooling air fan operates normally, or else start up standby fire detecting cooling air fan.
- 10) Find out the causes of the accident and report it to the superior.

10.8 Application for Boiler Shutdown

10.8.1 The Definiens of Application for Boiler Shutdown

When unit fault occurs, the operation parameters approach to limit values, but it will not cause serious effects, measures shall be taken to remedy, if it can be remedied, it shall be reported to shift leader and request to shut down the boiler because of fault.

10.8.2 The Conditions of Application for Boiler Shutdown

When the following conditions occur in boiler, operator shall request the shift leader to shut down the boiler:

- 1) Superheater of reheater pipe wall temperature exceeds the upper limit value, through load reducing and measures it still cannot be reduced to normal value.
- 2) Pressure bearing parts inside and outside the boiler leak because of any reason.
- 3) Quality of boiler feed water, water inside the boiler, or the steam is lower than the standard, and cannot recover after adjustments.
- 4) Boiler clinkering is serious and cannot maintain normal operation.
- 5) Single preheater breaks down, and cannot recover in short time.
- 6) Two ESPs stop, and cannot recover in short time.
- 7) Control air source is lost, and cannot recover in short time.
- 8) Steam temperature exceeds allowed value, and can recover after all kinds of remedies.
- 9) Boiler cannot extract slag for 12 hours.
- 10) Adjustment of water feed system is disabled, and can recover in a short time.
- 11) Safety relief valve or solenoid discharge valve acts, and cannot return to the valve seat after action.

10.9 Boiler MFT Conditions

Any of the Conditions below can set MFT memory: (OR)

Manual MFT (both MFT pushbuttons are depressed at the same time)

Both FDFs tripped

Both IDFs tripped

Both APHs tripped

Total airflow is <25%BMCR (2/3)

Drum level HH (2/3, delayed 20s)

Drum level LL (2/3, delayed 20s)

Turbine tripped and bypass doesn't open >5%(when boiler load>15% or furnace temp>580)

Furnace pressure HH (2/3)

Furnace pressure LL (2/3)

Lost primary air (both PAFs tripped when only mill in service)

Lost Flame Scanner cooling air (Both cooling air fans tripped or outlet main pipe press LL 2/3)

Unit flames failure (all coal elevations 3/4 no flame and no oil elevations is in service)

Loss fuel trip (two conditions OR: 1.when any oil burner ever set in service, “all ov closed or OFT” and “all feeders stopped”. 2. any oil burner ignite fail up to 3 times)

ALL feed water pumps tripped

Repurge requirement (MFT is reset but no firing up to 30 minutes)

FSSS cabinet power off (FSSS common logic cabinet power off)

All boiler circulating pumps tripped (three boiler circulating pumps tripped or three pumps inlet/outlet diff press low delayed 5s)

MFT will cause the following action:

Close oil trip valve, all corner oil valves. (Heavy oil and light oil)

Open return oil trip valve

Retract oil burner and igniter.

Trip all PAFs

Trip all mills

Trip all coal feeders

Close all mill outlet valves (mill discharge dampers and burner inlet isolation dampers)

Close SH spray water valve

Close RH spray water valve

Trip turbine

Trip generator

Trip Precipitator

Trip soot blowers

10.10 Boiler Fire Extinguishment

10.10.1 Phenomena:

- 1) MFT acts, CRT is alarming.
- 2) Flame TV doesn't show.
- 3) Furnace negative pressure increases.
- 4) Steam pressure and temperature decrease, and water level declines first and rises later.
- 5) Flame cannot be observed on Flame TV.

10.10.2 Causes:

- 1) The combustion is unstable, and fuel oil is not put into promptly to assist the combustion.
- 2) Mis-operation of operators
- 3) Boiler load is too low, adjustments are not proper, fuel and air ratio is not proper, or furnace negative pressure is too high.
- 4) Air damper or oil input valve is closed by mistake.
- 5) There are lots of water and foreign matters in fuel oil, which cause unsatisfied atomization or blockage of oil burner.
- 6) Coal quality is too bad, and adjustment is not in time.
- 7) RB occurs without proper handling measures.
- 8) Water wall explosion is serious, or boiler soot blowing operation is improper.
- 9) Combustion automatic adjustment is disabled.
- 10) When boiler operates with low load, boiler water sealing is interrupted, and lots of cool air is let in.
- 11) Auxiliary power is cut off.
- 12) Indication of fire detection for instruments is abnormal, and fire detecting protection act by mistake.

Handling:

Handle it as per MFT, and restart the unit after the causes are found out and removed.

10.11 One air preheater trips

10.11.1 Phenomena:

- 1) The alarm of “Air preheater trip” or “air preheater stop” on BTG panel, CRT is alarming, and motor current reaches zero.
- 2) All the gas or air dampers at inlet and outlet of air preheater are closed by interlock, and the ID fan, FD fan, and primary air fan on the same side are tripped by interlock.
- 3) Hot section sector plate lift up to “emergency lift” position automatically.
- 4) Primary and secondary manifold pressures decline, FD fan outlet pressure raises, the total air flow and oxygen content decline, and boiler RB acts.
- 5) Primary and secondary air temperatures decline, and temperature at mill outlet declines.

10.11.2 Causes:

- 1) Mechanical part breaks down, rotor is blocked or jammed, overload causes motor tripping.
- 2) Driving connections break down or bearing is damaged.
- 3) Electric part breaks down and trips.
- 4) Mis-operation of manual part or control part.
- 5) Protection acts.
- 6) Sealing is too tight.

10.11.3 Handling:

- 1) If there is no over current or blockage before air preheater tripping, then restart air preheater once, if successful, then recover to normal operation.
- 2) If the restart is not successful, close the dampers at inlet and outlet of air preheater, and check the following locally.
 - a) Check if auxiliary driving is interlocked or not.
 - b) Check main driving device breaks down or not.
 - c) Check if parameters are normal or not.
 - d) Check if sector damper at hot section lifts to the highest position, or else it shall be lifted manually to the highest position after air preheater tripping for 15 minutes.
- 3) When manual barring gear is flexible and main driving device is normal:
 - a) Close the switch of main driving device, if successfully, then switch to normal operation; if unsuccessfully, then close the switch of auxiliary driving device, and request electric part to recovery the main driving device.
 - b) If closing the switches of main and auxiliary driving device are unsuccessful, then operate manual barring gear during maintenance period, and recover main and auxiliary motor as required.
- 4) If the air preheater haven't been rotated in 15 minutes after air preheater is tripped, then the main and auxiliary motor and pneumatic motor is prohibited to be started up.
- 5) When one air preheater is tripped, the other three coal mills shall remain operating. Then put into oil burners for the operating coal mill, and reduce the load to 360MW.
- 6) If mechanical part breaks down and manual barring gear is disabled, then the air preheater inlet and outlet dampers shall be closed for maintenance.
- 7) If the air preheater cannot be recovered in short time, then the air preheater can be stopped after the

temperature at the gas duct in front of the air preheater is reduced to 200℃ below.

10.12 Air Preheater on Fire

10.12.1 Phenomena:

- 1) Air preheater outlet gas temperature rises abnormally.
- 2) Primary and secondary air temperature of air preheater rise abnormally.
- 3) Supervising device of sealing alarms and adjusts frequently.

10.12.2 Causes:

- 1) Air preheater heat component has large accumulated flammable matters.
- 2) Boiler starts up and shuts down frequently, and operates with high proportion of fuel oil ratio for a long time.
- 3) The soot blowing and cleaning are not carried out as regulated.
- 4) Air preheater has lost monitor of gas temperature during hot standby period.

10.12.3 Handling:

- 1) Trip boiler fuel, and shut down boiler emergently.
- 2) Shut down the ID fan, FD fan and primary fan on corresponding side immediately.
- 3) Close air preheater inlet and outlet dampers of air preheaters, and keep the access door closed.
- 4) Close cooling air damper at primary air fan outlet.
- 5) Maintain rotation of air preheater.
- 6) Open the water discharge outlet at air preheater lower ash hopper, open valves of upper and lower cleaning pipes, put into fire fighting water. The cleaning water valve can only be closed after the fire is extinguished completely.
- 7) If the fire is strong, water tap can be applied to extinguish fire.
- 8) If the air preheater catches fire during hot standby period, the driving device of air preheater shall be put into first, then extinguish the fire.
- 9) Check if rotor and sealing are normal or not after fire extinguishment.
- 10) Check if the ash tank of air preheater is normal or not, and check the water discharge valve of primary air fan and FD fan outlet, and open the valve to discharge water completely.
- 11) Dry the air preheater completely.

10.12.4 Measures to Prevent Air Preheater from Catching Fire

- 1) Reduce startup and shutdown times.
- 2) Shorten the time of operation with high proportion of fuel oil.
- 3) Carry out normal soot blowing and regular cleaning.
- 4) Reinforce gas temperature monitor, and reinforce gas temperature variation of air preheater upper under the conditions of hot standby and sudden shutdown by fault.

Air leakage control system of air preheater breaks down.

When the alarm of air leakage control system of air preheater is alarming, it shall be confirmed promptly.

When the following conditions happen, air preheater control system send out alarm will ring.

- 1) Journey switch of upper limit acts.
- 2) Journey switch of lower limit acts.
- 3) Transmitter breaks down.
- 4) Motor1 overload
- 5) Motor2 overload
- 6) Main shaft A of air preheater stops rotation or rotates at too low speed.
- 7) Main shaft B of air preheater stops rotation or rotates at too low speed.
- 8) The branch power supply in cabinet is tripped.

When the transmitter is abnormal, operate under manual mode.

When motor is overload, reset corresponding relays in cabinet.

When motor breaks down or loses power, manually lift up the sector plate.

10.13 Sudden Load Reducing

10.13.1 Cause

- 1) System impact and fluctuation
- 2) Generator step out
- 3) Control circuit fault
- 4) EH oil pressure fluctuation
- 5) Boiler abnormal operation, mis-operation of HP or LP bypass, sudden stop of steam extraction bleeding back

10.13.2 Handling

- 1) Find out causes according to the display on screen, indications on instruments, and external characteristics.
Carry out overall inspections of all systems and parameters to see whether they are normal.
- 2) If system oscillation occurs, promptly carry out relative operations as per the order of the shift leader.
- 3) During generator step out, the active power of generator shall be reduced, and excitation shall be strengthened manually.
- 4) If the sudden load change of the unit is caused by the frequency change of the power grid, the output of the unit shall be strictly controlled. It is prohibited to operate the unit with over output.
- 5) Control circuit fault shall be handled by maintenance party immediately.
- 6) EH oil pressure fluctuate shall be handled as per EH system fault handling.
- 7) If it is caused by boiler abnormal operation, then the parameters shall be kept stable.

If it is caused by mis-operation of HP or LP bypass, the bypass shall be recovered to normal.

10.14 Auxiliary Power Interruption

10.14.1 Phenomena:

- 1) Emergency alarm is ringing, unit is tripped.
- 2) Work illumination is went out. Emergency illumination is lighted up, and the control room is dark.
- 3) The operating AC motors are stopped, standby motors are not started by interlock, and current indications are zero. The DC lube oil pump of the Steam-Driven FWP and the unit, DC lube oil pump and DC sealing oil pump are started automatically.
- 4) "low voltage" alarm for 6kv bus bar is ringing, low voltage protection actuate tripping of partly load.
- 5) The CB between emergency power supply of auxiliary power to emergency power section is closed, diesel oil power generator unit is started automatically, 400V central control emergency PC switching automatically.

10.14.2 Causes:

- 1) Generator is tripped, at the same time the startup & standby transformer is in stop status or the standby power supply is failed to put to automatically.
- 2) Auxiliary power is supplied by startup & standby transformer, but the startup & standby transformer is tripped.
- 3) 400KV system voltage loss.

10.14.3 Handling:

- 1) Check the emergency power supply of auxiliary power, and close the CB of emergency section, then diesel oil starts up automatically and successfully, or else manually start up emergency diesel oil power generator and close the CB of emergency power supply of auxiliary power.
- 2) Check if the emergency power supply of auxiliary power under with good contact condition, the incoming line CB of standby power supply of boiler, turbine, desulphurization emergence section is closed normally, and emergency MCC power supply is normal, and then start up the load of emergency section.
- 3) If standby power supply is normal, check if there is signal of “branch overcurrent”, “zero sequence overcurrent” or “6kv bus bar lock switching”. The standby power supply can compulsively supply power to the unenergized bus bar once, if it is failed, it is prohibited to supply power. Before compulsive power suppling, the power CB shall be confirmed to be in break off position.
- 4) Check if charging devices and UPS power supply of DC current system are normal.
- 5) Manually break off all the CBs of untripped load on 6kv unenergized bus bar.
- 6) Check and confirm that the CB at generator-transformer uinit, excitation CB, and power supply CB of 6kv work power are tripped automatically.
- 7) Confirm that the turbine is tripped, turbine roatation speed declines, HP main steam vlave, HP regulating valve, LP main steam valve, LP regulating valve are closed, HP exhaust check valve and steam extraction valve is closed. AC lube oil pump, hydrogen standby sealing oil pump operate normally. Check if the seal oil pressure is normal.
- 8) Confirm that the quick-close valve and regulating valve of steam driving FWP are closed; motor-operated valve of steam extraction stage 4, motor-operated valve of cold reheat steam supply, motor-operated valve of auxiliary steam are closed, and the rotation speed declines.
- 9) The power supply of emergency section cannot be recovered. Confirm that the DC emergency lube oil pump of BTG and DC sealing oil pump are started automatically. If not, put into them manually. Check if the lube oil pressure is normal. Adjust the differential pressure of sealing oil and hydrogen to be around 0.056MPa. Confirm that the steam-driving FWP is tripped, and the emergency oil pump of the steam-driving FWP is started automatically, or else they shall be put into manually.
- 10) Confirm that boiler MFT acts, oil burners are tripped, fuel oil is tripped, fuel tripping valve is closed automatically, the dampers of hot and cool air at inlet of coal mill are closed.
- 11) Confirm that the power supply CB for auxiliary emergency power to emergency section is closed successfully, the diesel oil generator is started up automatically and successfully, and emergency power supply is recovered

- automatically. If not, they shall be checked locally. The diesel generator will be started up manually and the emergency power supply shall be recovered after the faults are eliminated.
- 12) Confirm that the flame scanner cooling air fan operates normally, or else manually start up a flame scanner cooling air fan.
 - 13) Check if the cooling water discharge valve of the heat insulation of boiler water circulating pump is opened or not.
 - 14) Corresponding drain valves shall be opened after turbine tripping. Drain valve after the check valve of HP steam exhaust. Close the manual valve in front of the drain valve before check valve of HP steam exhaust. Close the manual valve in front of the drain regulating valves on two sides. Make sure the main steam drain pneumatic valve and manual valve are closed. Close the manual valve and pneumatic valve of main steam branch A, close the drain valve and pneumatic valve of main steam branch B. Confirm that the HP and LP bypass valves are closed, and isolate the drain water from entering condenser.
 - 15) The voltage of emergent power section is normal, check if UPS, 220VDC, 220VDC system are normal, if the voltage is normal.
 - 16) Start up AC oily gas extracting fan of main oil tank.
 - 17) Start up oily gas extracting fan of steam-driving FWP, the rotation speed of steam-driving FWP declines to 500rpm below, start up motor of the barring gear of steam-driving FWP and listen to the sound of it locally.
 - 18) Start up lube oil pumps of ID fan, primary air fan, and coal mill.
 - 19) Start up the AC lube oil pump, confirm that the voltage at the outlet is normal, and stop and switch to standby the DC emergency lube oil pump. During turbine idle running period, pay attention to listen to the sounds from parts of the turbine, check if the differential expansion of HP and LP cylinder, vibration, axial displacement, eccentricity, barring gear current is normal, and ensure that the return oil temperature of every bearing declines. After turbine rotation speed declines to 1000rpm, confirm that the jacking oil pump starts up automatically, rotation speed reaches zero, and barring gear puts into automatically, or else they shall be put into manually. If there is abnormal sound in turbine, the vacuum shall be broken and the unit shall be shutdown, and the idle running time shall be paid attention to.
 - 20) Monitor the turbine lube oil temperature strictly, and put into oil cooler parallelly if necessary. If the lube oil temperature is higher than 45°C, shut down continue barring gear operation, and manually rotate the barring gear for 180 degree once every 20 minutes.
 - 21) Steam source of turbine gland sealing is supplied by auxiliary steam. When the vacuum reaches zero, open vacuum break valve, close manual valves of the main steam, cold reheat steam, and the auxiliary steam supplied to gland sealing.

- 22) Confirm the air preheater main motor is started up automatically, and listen to the sound to check if the air preheater runs normally. If necessary, manually rotate the air preheater.
- 23) Inform the I & C to stop the chemical dosing system as soon as possible, and quit the sampling system.
- 24) After the air supply failure of instrument air, control the steam source as per chapters of control air source failure.
- 25) Before auxiliary power is recovered, the acted protections and alarms shall be checked and recorded, all the 6kv motors' power supply CB shall be opened to prevent them from automatic starting up after sudden power on, and to facilitate recovery of auxiliary power system.
- 26) Inform maintenance personnel, check out the reason why automatic put into of startup & standby tripping or 6kv standby power source is failed. And then eliminate faults, and recovery the power supply of auxiliary power. Emergency section shall be switched to normal mode, the emergency section shall apply instant stop method. Before instant stop of the power supply of the emergency section, the load shall be transferred in order to prevent from oil cut, hydrogen leakage. The diesel oil generator shall be stopped, and the fuel oil shall be filled in its oil tank to the normal level, and then diesel oil generator shall be switched to standby.
- 27) After recovery of auxiliary power, gradually start up the closed cooling water system, compressed air system, and condensate system.
- 28) When turbine LP cylinder exhaust temperature is higher than 50°C, after the condensate system startup, the water sprayer and LP cylinder water spray to cool the cylinder. When cylinder exhaust temperature is lower than 50°C or the differential temperature of exhaust temperature and circulating water is lower than 30°C, the circulating water pump can be operated.
- 29) After circulating water pump is started up, open the turbine manual drain valves, and switch them to automation.
- 30) Start up a set of AC oil pump of pneumatic feed water pump, and switch another set to standby, and stop DC oil pump and switch it to standby.
- 31) Start up AC sealing oil pump, stop DC sealing oil pump and switch it to standby.
- 32) Gradually recover all systems, and make good preparation for unit hot startup.